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Value Creation from Complements in Platform Markets: Studies on the Video Game Industry

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A dissertation submitted in satisfaction of the requirements for the degree of
Doctor of Philosophy

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TABLE OF CONTENTS

1. INTRODUCTION	1
2. NINTENDO: FIGHTING THE VIDEO GAME CONSOLE WARS	7
2.1. Introduction	7
2.2. Swimming Up River.....	8
2.3. Jockeying for Position	11
2.4. The Comeback	16
2.5. Looking to the Future	19
2.6. Figures.....	21
3. DEMAND HETEROGENEITY AND THE ADOPTION OF PLATFORM COMPLEMENTS	25
3.1. Introduction	25
3.2. Two-sided Markets.....	29
3.3. Complement Adoption in Two-sided Markets	31
3.3.1. Demand Heterogeneity and Social Learning	31
3.3.2. The Adoption of Innovative and Superstar Complements	35
3.3.3. Synthesis	38
3.4. Research Setting and Methodology	39
3.4.1. The Market for Console Video Games in the United Kingdom (2000-2007).....	39
3.4.2. Data and Measures	41
3.4.3. Dependent Variable	41
3.4.4. Main Effects.....	42
3.4.5. Controls.....	44
3.4.6. Endogeneity	46
3.4.7. Analytical Approach	48
3.5. Results	50
3.5.1. Main Models	50
3.5.2. Innovative Video Games.....	52
3.5.3. Superstar Video Games.....	54
3.5.4. Robustness Testing and Alternative Explanations	55
3.6. Discussion	59
3.7. Conclusion.....	63
3.8. Tables & Figures	64
4. NEW HORIZONS OR A STRATEGIC MIRAGE? ARTIST-LED-DISTRIBUTION VERSUS ALLIANCE STRATEGY IN THE VIDEO GAME INDUSTRY	74
4.1. Introduction	74
4.2. The Role of Specialized Complementary Assets in the Commercialization of Technological Innovations	76
4.2.1. Why Small Firms Should (Not) Form a Strategic Alliance	78
4.2.2. Artist-led-distribution Versus Strategic Alliance in Creative Industries	80
4.2.3. Specialized Complementary Assets in the Creative Industries	83

4.3. Methodology	86
4.3.1. Empirical Setting: The Market for Digitally Distributed Games	86
4.3.2. Case Study Approach.....	87
4.3.3. Data Collection	88
4.4. Results	90
4.4.1. Artist-led-distribution Strategy	90
4.4.2. Strategic Alliance Strategy: Specialized complementary assets	92
4.4.3. Results Comparison	94
4.5. Discussion	95
4.6. Limitations and Future Research.....	100
4.7. Tables & Figures	102
5. GAME CHANGERS: BUSINES MODEL INNOVATION IN THE UK MARKET FOR DIGITAL VIDEO GAMES	106
5.1. Introduction	106
5.2. Content Production in the Creative Industries	109
5.3. Business Model Innovation in the Creative Industries	111
5.3.1. External Actor Dependencies.....	111
5.3.2. End-User Engagement	113
5.4. Methodology & Data Collection	115
5.4.1. The UK Market for Digital Games	115
5.4.2. Methodology	118
5.4.3. Data Collection: <i>Survey analysis</i>	118
5.4.4. Measuring Business Model Implementation	121
5.5. Results	124
5.5.1. A Cognitive Account of Business Model Innovation	124
5.5.2. Novel Business Model Implementation	127
5.6. Discussion & Conclusion	132
5.6.1. Discussion.....	134
5.6.2. Limitations and Future Research	136
5.7. Tables & Figures	139
6. CONCLUSION	148
REFERENCES	154
APPENDIX A: FIRST STAGE REGRESSION RESULTS (CHAPTER 3)	165
APPENDIX B: SURVEY ITEMS (CHAPTER 5)	169
APPENDIX C: PUBLICATIONS, PRESENTATIONS & KNOWLEDGE TRANSFER	170

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ABSTRACT

Value Creation from Complements in Platform Markets: Studies on the Video Game Industry

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This dissertation is comprised of three empirical studies that examine the effect of platform-level variation on value creation strategies and market performance for providers of complementary goods (“complementors”) in platform-based markets. The studies all investigate the video game industry as a canonical example of a platform market. Three empirical studies are preceded by an industry chapter outlining the evolution of the video game industry as perceived by one of the industry’s key actors: Nintendo.

How does platform maturity affect the adoption of complements in two-sided markets? A key feature of two-sided markets is the existence of indirect network effects. In the first empirical study, I argue that demand heterogeneity from end-users adopting the platform at different points in time, moderates the extent to which complements enjoy these indirect network effects. An inflow of late adopters that buy fewer complements and mimic earlier adopters’ adoption behavior, increasingly offsets the benefits of a growing installed base. Using a dataset of 2,855 sixth-generation console video games, I find that platform maturity has a concave curvilinear effect on video games’ unit sales. Platform maturity, however, does not affect all

types of games equally. Late adopters increasingly favor non-novel video games at the cost of innovative ones. Furthermore, the adoption disparity between superstars and less-popular video games also widens as platforms mature.

In the second empirical study, I and my co-authors (Joseph Lampel and Thijs Broekhuizen) contribute to the debate between researchers who argue that the emergence of online distribution platforms allow content producers in the creative industries to bypass powerful publishers and distributors, and other researchers who argue that this strategy cannot succeed without the complementary assets that these intermediaries provide. We use a case study of the Dutch Video Game Developer (DVGD) bringing to market an identical video game using two different but comparable distribution platforms as a quasi-experiment: in the first release DVGD used online distribution to reach consumers directly, whereas in the second it used an alliance with an established video game publisher. We find that, while the alliance required DVGD to share with the publisher a substantial fraction of the value appropriated by the game, the alliance strategy resulted in greater absolute financial performance and relative market performance compared to the self-publishing strategy. We conclude that the differences in performance can be traced back to specialized complementary assets required for successful commercialization.

Technological change, such as the advent of digital distribution platforms, facilitates the implementation of novel business models. Yet, we know little about how managers make sense of novel pathways for doing business after the emergence of a widespread technological change. The third empirical study aims to shed light on this issue by asking why managers in the context of the video game industry changed their business models following the advent of digital distribution platforms, and how? A mixed-method study comprised of a sector-wide survey and

four in-depth case studies in the market for digital video games in the United Kingdom provides insight into managers' reasons and motivations. I and my co-authors (Joost van Dreunen and Charles Baden-Fuller) find that managers moved away from the *de facto* work-for-hire business model into three novel business models: artist-led-distribution; freemium; and multisided. In changing their business models, managers do not have increased economic gains as solitary objective per se. Instead, novel business models offer ways of doing business in which a cognitive tension between important organizational objectives – a desire for creative autonomy versus mitigation of financial risks – can be resolved in alternative and typically preferred ways.

Keywords: *multisided platforms; complementors; demand-perspective; complementary assets; business models; video games.*

To My Dear Grandfather, Gerrit Rietveld (1929-2013)

1. INTRODUCTION

With the advent of the digitization of information, platform-based markets have surged in terms of their presence and economic relevance. Mobile operating systems such as Android and Apple's iOS, Google's Internet search engine, Facebook's social networking service, and video game consoles such as the Nintendo Wii all are examples of platform markets. Platform markets differ in their dynamics from 'normal' markets due to their *multi-sidedness*: a video game platform is comprised of end-users who buy video games and producers of video games. The platform owner, then, is presented with the challenge of getting "both sides on board" where it often finds itself having to solve a typical chicken-and-egg problem (Caillaud & Jullien, 2003; Rochet & Tirole, 2003; Rysman, 2009). Indeed, providers of complementary goods (or, complementors) will, to large extent, equate the value of a platform with the size of its installed user base, and vice versa (Clements & Ohasi, 2005; Dubé, Hitsch & Chintagunta, 2010; Stremersch *et al.*, 2007). To tackle these complex coordination puzzles, platform owners deploy price and governance strategies that are distinct from the strategies of firms operating in industries subject to traditional market forces (Boudreau, 2010; Boudreau & Hagiu, 2009; Cennamo & Santalo, 2013; Gawer & Cusumano, 2002; Parker & Van Alstyne, 2005; Seamans & Zhu, 2014; Wareham, Fox & Giner, 2014).

Research on (multisided) platforms has grown exponentially in the last decade (for an overview, see Jacobides, Cennamo & Gawer, 2015). Academic work on platforms originated in the economics literatures where scholars are primarily interested in platforms' price-setting strategies as a means of stimulating cross-platform adoption rates (Caillaud & Jullien, 2003; Rochet & Tirole, 2003; 2006). As such it is seen as a subset of the literature on network effects

(Katz & Shapiro 1986; Rysman, 2009). Scholars in marketing and information systems have subsequently built on these theoretic principles to empirically test and refine them by studying variance on the complements side that may moderate the magnitude of cross-platform externalities such as complement popularity (Binken & Stremersch, 2009), complementors' market entry strategies (Corts & Lederman, 2009; Landsman & Stremersch, 2011), and platform owners' integration into the complement side (Hagiu & Spulber, 2013; Lee, 2013). Recent research in the domain of management studies has loosened some of the restrictive assumptions stipulated in the economics literature to include engineering perspectives to see platforms as regulatory and facilitative devices that provide modular technological architectures in which complementors can innovate to achieve economies of scope in innovation and supply for the entire platform or, ecosystem (Adner & Kapoor, 2010; Boudreau & Hagiu, 2009; Gawer & Cusumano, 2002). From a management perspective platforms can then be seen as evolving "meta organizations" that federate and coordinate complementors who can innovate within the technological architecture facilitated and regulated by the platform (Gawer, 2014; p. 1240).

This definitional expansion has two important implications that open up avenues for future research. First, it sees platforms as dynamic organizations (rather than static and exogenous entities) with strategic instruments at their disposal beyond mere price-setting. Platform owner regulation (or, governance) has been documented to positively affect the outcomes of platform competition and platform owner value creation in several cases including social networking site Facebook, software outsourcing platform Top Coder, and a large enterprise resource planning platform (Hagiu & Boudreau, 2009; Wareham *et al.*, 2014). The second advantage the management perspective on platforms brings, and simultaneously the core focus of this dissertation, is that it takes the complementor that innovates and competes within

the confinements of the platform as a focal actor of inquiry. The economic principles of platforms' *multisided-ness* and rule-setting, facilitative and federating behavior make for a dynamic institutional environment where complementors are faced with a distinct set of competitive rules that affect market entry decisions and modes, value creation strategies, and ultimately, competitive outcomes. The study of complementors and platform complements ought, therefore, not to be conflated with the study of firms and products solely through traditional conceptual frameworks such as complementary assets, the resource-based view of the firm, or classical 'Porterian' competitive analysis. Whilst informative and useful, such endeavors may lead to incomplete and biased results if the platform is excluded from analysis.

Indeed, studying complementors in platform markets was recently identified as an avenue for future research with many "big ticket" questions still unanswered (Jacobides *et al.*, 2015). Building on this insight, this dissertation seeks to answer the following research question: *How does platform-level variation affect value creation strategies and market performance for complementors in platform-based markets?*² From a complementor's perspective, platform-level variation can be observed within platforms (intra) and between platforms (inter). Furthermore, the term can be used to refer to governance mechanisms imposed by the platform owner as well as to changes on the platform side that go beyond the scope of the platform owner's influence spheres. The difference barriers to entry observed when comparing Nintendo's home video game consoles and Google mobile Play platform is an apt example of inter-platform variation that is part of the platform owners' governance mechanisms. Nintendo deliberately sets high barriers to

² I use the term value creation strategy consistent with Bowman and Ambrosini's (2000) definition of the term – value is jointly created between firms in the value chain and is assessed from a customer's or end-user's perspective. In my case, I study focal firms (complementors) as orchestrators of the value creation process (i.e. strategy) and measure the outcomes of these strategies by observing customer responses in the form of unit sales or revenue sales (market performance). Chapter 4 is the only chapter that looks at value capturing strategies as it specifically studies the focal firm's share of revenues accrued vis-à-vis other firms in the value chain following two distinct value creation strategies.

platform entry as it wants is complementors to deliver fewer high quality video games, while Google aims for large volumes of apps and games with a wide range of different qualities. Shifts in demand composition on the end-users side of platforms, as documented in chapter 3, fall under intra-platform variation that is somewhat exogenous to the platform owner. A platform owner changing its internal platform policies, such as Apple's recently implemented 14-day no questions asked refund policy for apps purchased in the App store, would be an example of an intra-platform variation caused by the platform owner changing its governance mechanisms.³

Notwithstanding the theoretical justification for this question, it should be noted that there exists tremendous practical relevance in developing a complement-centric research agenda, too. By rule of design, the ratio of complements-to-platforms unequivocally favors complements. In January 2015, there were 361,560 active apps publishers on Apple's App Store, responsible for nearly 1.5 million active apps.⁴ In terms of economic relevance, complements contribute significantly to platforms' overall value-add. In the U.S. video game industry in 2013, 70% of estimated \$21.53 billion sales came from game sales with the remainder coming from platform sales and peripheral products such as input controllers (ESA, 2014). Studying performance is particularly salient as market outcomes for complements tend to be skewed with a small number of 'killer apps' responsible for the majority of sales. When the controversial video game *Grand Theft Auto V* was released in September 2013 for Sony's PlayStation 3 and Microsoft's Xbox 360 platforms, it shattered sales records by becoming the fastest entertainment property to reach the one billion dollar sales threshold in just three days.⁵ By virtue of their contractual agreements

³ <http://www.macrumors.com/2014/12/29/eu-14-day-itunes-app-returns/> - last accessed May 21, 2015.

⁴ <http://www.pocketgamer.biz/metrics/app-store/> - last accessed January 26, 2015.

⁵ <http://www.forbes.com/sites/timworstall/2013/09/20/grand-theft-auto-v-is-fastest-selling-entertainment-property-ever-which-makes-willy-hutton-look-pretty-foolish/> - last accessed January 26, 2015.

with the game's publisher, Take 2 Interactive, platform owners Sony and Microsoft collectively accumulated an estimated \$200 million dollar in royalty payments during this period.⁶

The empirical studies that comprise this dissertation are among the first to take a complementor-centric perspective on platform markets. Having said that, the works stand not in isolation as they build on earlier studies that take a similar perspective (Boudreau, 2012; Boudreau & Jeppesen, 2014; Venkatraman & Lee, 2004). My aim in this dissertation is not as much to arrive at a comprehensive list of platform-level variations and how they impact complementors' value creation strategies and market performance, much rather to document that platform variation indeed exists, and as such, that it is academically relevant to include a complementor-centric perspective in platforms research. The dissertation's 'identification strategy' is one of three empirical studies with different methodologies within a single industry setting, the market for video games. The video game industry was chosen, personal interests and past working experience aside, as games have frequently been heralded as a "canonical" example of a two-sided platform (e.g. Cennamo & Santalo, 2013; Clements & Ohashi, 2005; Seamans & Zhu, 2014). Through both qualitative quantitative inquiry, I document ample instances of *intra* platform-level variation (e.g. demand heterogeneity on the end-user side) and *inter* platform-level variation (e.g. barriers to market entry for complementors) effects on complementors' value creation strategies (e.g. mode of market entry) and market performance outcomes (e.g. cumulative unit sales). The dissertation's findings and conclusions aspire to inform, propel and stimulate future research on complementors and complements in platform-based markets.

⁶ In her analysis of the global console video game industry, Johns (2006) finds that platform owners such as Sony and Microsoft accrue an average of 20% of the total retail value from every game sold on their platforms.

Three empirical studies are written up in such fashion that the chapters act as standalone research papers with the (eventual) aim of submission to an academic journal. Given its recurring and central position, chapter 2 acquaints the reader with the video game industry by offering an account of its evolution as perceived by one of the industry's key actors: Nintendo. Chapters 3 – 5 present the results of three empirical studies. Chapter 3 studies the effect of a platform's evolving end-user base on the market performance of 2,855 sixth generation console video games in the United Kingdom (2000–2007). The chapter concludes that the magnitude of cross-platform network externalities for complements is moderated by the composition of end-users that enter the platform at different points in the platform lifecycle. Chapter 4 studies the effect of strategic bypassing of specialized complementary asset owners by upstream content developers by taking advantage of a naturally occurring quasi-experiment of a Dutch digital games developer bringing to market identical content onto two comparable digital distribution platforms using distinct commercialization strategies (2008–2009). Chapter 5 builds on some of the results from chapter 4 and studies how digital distribution platforms' increased degrees of freedom (vis-à-vis boxed products distribution channels) for complementors' business model designs has led to video game developers in the United Kingdom to conceive of and implement novel business models (2012–2013). The chapter utilizes a proprietary dataset of 41 executive-level survey responses and four firm-level case studies. Chapter 6 synthesizes and aggregates the dissertation results and provides some concluding remarks.

2. NINTENDO: FIGHTING THE VIDEO GAME CONSOLE WARS⁷

2.1. Introduction

The 2011 Electronic Entertainment Exposition (E3) in Las Vegas was a moment of truth for Nintendo, video games' most iconic company. Despite the recent success of its flagship product, the Wii video game console, Nintendo was facing decreasing sales and lower revenues. The company's hardware sales were down by 10 million units compared to 2009, and software sales were down by 30 million units compared to 2009. Income was in decline, and shares seemed to be in permanent retreat. Nintendo's stock had retreated to levels not seen since the company's mediocre performance before the launch of the Wii.

--- INSERT FIGURE 2.1 HERE ---

Nintendo's problems were taking place at a time when the industry's standard business model was being transformed by online social, and mobile gaming – market segments that Nintendo had been reluctant to enter. For many observers Nintendo's problems could be traced back to Nintendo's conservative management style and incremental innovation policy. Nintendo was still very much a family-owned and managed business. Long time CEO Hiroshi Yamauchi, great-grandson of Nintendo founder Fusajiro Yamauchi, continued the top-down management

⁷ This chapter was written under the supervision of Professor Joseph Lampel at Cass Business School. The manuscript was submitted and accepted for publication in February 2013 as an invited teaching case in *The Strategy Process* (ed. Lampel, J. and Mintzberg, H.). The chapter's preferred reference is:

Rietveld, J. and Lampel, J. (2014). Nintendo: Fighting the Video Game Console Wars, *The Strategy Process* (in ed. Mintzberg, H. *et al.*), Fifth Edition, FT Press.

This dissertation chapter was revised from the teaching case with cosmetic edits to improve readability. Beyond the sources cited in this chapter, information was retrieved from many online available sources such as Nintendo's Investor's Relation repository, fiscal reports, and databases documenting worldwide sales for home video game consoles (i.e. VGChartz). The case also relies on a few interviews with industry experts that were conducted as part of an earlier study I did in 2008. Informants include a marketing director at Nintendo Europe, an expert journalist, and an analyst for the video games industry.

3. DEMAND HETEROGENEITY AND THE ADOPTION OF PLATFORM COMPLEMENTS⁸

3.1. Introduction

In two-sided markets such as video games, operating systems and newspapers, the availability of popular complements is paramount to a platform's success (Gawer, 2014; Schilling, 1998; 1999; 2002; Wareham, Fox & Giner, 2014). It was, for example, the immensely popular video game *Tetris* that led to Nintendo's dominance in the handheld video game market with the Game Boy in the early nineties. Similarly, the American Broadcasting Company (ABC) quickly realized the importance of quality content in persuading viewers to migrate from black-and-white television sets to color TVs in the early sixties. Licensing exclusive Disney content helped ABC attract a critical mass of color TV adopters.

The powerful influence of complements on platform growth inspired researchers on two-sided markets (Rochet & Tirole, 2003; 2006), platform markets (Schilling, 1998; 1999; 2002), and technology ecosystems (Adner & Kapoor, 2010) to focus on how changes on the complements side affect competition on the platform side. A key theme is the notion of indirect network effects: an increase in the number of complements supporting a platform causes a temporal surge in platform adoption by end-users (Clements & Ohashi, 2005; Parker & Van Alstyne, 2005; Stremersch *et al.*, 2007). Recent studies have also looked at the heterogeneous effect of different *types* of complements on platform adoption (Cennamo & Santalo, 2013; Corts

⁸ The research and write up of this research was conducted during an extensive visiting period with NYU's Stern School of Business (Department of Management & Organizations). I am greatly indebted to JP Eggers and Melissa Schilling for their regular feedback and actionable advice. I am also indebted to Masakazu Ishihara, Rob Seamans, Stefan Haeffliger, David Nieborg, Anil Doshi, Cristiano Bellavitis, the participants of a doctoral brownbag, the participants of the 2013 *NYU Columbia Doctoral Conference*, and participants of the 2014 *Platform Strategy Research Symposium*. I thank three research assistants for their data collection efforts and Andy Webb for his insights on the UK video games industry. All mistakes are my own.

& Lederman, 2009; Landsman & Stremersch, 2011; Hagiu & Spulber, 2013). For example, Binken and Stremersch (2009) find that superstar complements – complements of high quality and high popularity – positively affect platform sales over and above the indirect network effects from the number of complements available for the platform.

While the literature on two-sided markets in economics has been swift to point out that heterogeneity on the *sellers* side can have differential effects on platform adoption, no accounts exist of how heterogeneity on the *buyers* side affects competitive dynamics for complementors. While at first one may assume there is a simple correlation in growth (i.e. more end-users adopting the platform leads to greater complement adoption), this may not always hold. As a platform's installed base grows, its composition also changes (Von Hippel, 1986). Late adopters of platforms may have different motives, preferences and constraints that affect not only the number of complements adopted, but also the *types* chosen. This paper aims to explore these dynamics by posing the following research question: *How does platform maturity affect the adoption of complements in two-sided markets?* This is an important question that is distinctively different from standalone innovation adoption puzzles as discussed by the technology lifecycle or dominant design literatures (Abernathy & Utterback, 1978; Dosi, 1982; Utterback & Abernathy, 1975). Platforms are “evolving meta-organizations,” and platform owners purposefully govern their ecosystems by coordinating and federating complementors and end-users (Gawer, 2014).⁹ In this paper, I thus contribute to the literature on platform competition by exploring how one form of intra-platform evolution (changing end-user composition) affects the competitive dynamics for the constituents (complementors) operating within a focal platform.

⁹ Following Gawer (2014) and Gawer & Cusumano (2014) I use the terms ‘provider of complementary goods’ and ‘complementor’ interchangeably. Brandenburger and Nalebuff (1996) classify products as complements when greater sales of one product increase demand for the other (e.g. video game consoles and video games).

Using the diffusion of innovations as a theoretical base, my main thesis is that the adoption of complements is affected by a growing installed base that changes composition over time. The evolution of technological innovations is inherently linked to demand heterogeneity (Adner & Levinthal, 2001; Adner, 2002). Early adopters of an innovation are qualitatively different from late adopters. Late adopters typically are risk-averse, ill-informed, and price sensitive compared to early adopters (Rogers, 2003). Furthermore, while early adopters peruse external information sources, late adopters are backward looking in that they tend to copy early adopters' adoption patterns (Banjeree, 1992; Bikhchandani, Hirshleifer, & Welsh, 1992). In two-sided markets, increases of late adopters entering the platform lead to an interesting dynamic where complements that are released late in the platform lifecycle face a markedly larger addressable audience than do complements that are released early. The benefit of the larger installed base, however, is juxtaposed by its composition. Complements that are released early face fewer end-users, but those users might be generally more inclined toward adopting many and different *types* of complements, while complements that are released late face a larger number of end-users, but they are backward looking and more selective in their choice of complements.

To analyze these dynamics, I use a dataset of 2,855 video games released in the UK between 2000 and 2007 on three competing platforms effectively spanning the entire sixth generation of consoles (i.e. Nintendo GameCube, Sony PlayStation2, and Microsoft Xbox). The market for video games has often been described as a canonical example of a two-sided market (Cennamo & Santalo, 2013; Clements & Ohashi, 2005; Dubé, Hitsch & Chintagunta, 2010). Worldwide sales for the video game industry are projected to reach \$100 billion in 2014, with over 70% of sales coming from video games and the remainder from hardware and accessories

(ESA, 2013)¹⁰. The most popular video game to date is *Grand Theft Auto V*, which generated sales in excess of \$1 billion only three days after its market launch in September 2013. Video game consoles are a particularly fitting setting given their generational nature. Hardware systems have clearly demarcated beginnings and ends, and the timing of competing consoles that are part of the same generation typically occurs within an eighteen months timeframe. I utilize the variance in platform maturity across competing video game consoles to run a game-fixed effect specification for games that are launched on more than one platform. By doing so, I effectively rule out alternative explanations that are caused by unobserved heterogeneity at the complement level.

The paper contributes to the growing body of work in platform studies that takes the complementor as focal unit of analysis (Boudreau, Lacetera & Lakhani, 2011; Boudreau, 2012; Boudreau & Jeppesen, 2014). Competitive dynamics within platform markets are different from the dynamics in markets that are single-sided, which makes the study of complementors worthy in its own right. The notion that the outcomes of the aforementioned competitive dynamics can have a non-negligible impact on platform competition (Binken & Stremersch, 2009; Lee, 2013), makes the study of complementors particularly relevant for a growing community of strategy scholars that study platform competition. The paper further aims to contribute to the burgeoning research on demand-based perspectives in strategic management that has been criticized for having a “supply-side bias” (Adner, 2002; Adner & Levinthal, 2001; Adner & Zemsky, 2006; Priem, 2007). The findings offer a first step toward understanding how demand heterogeneity in two-sided markets affects competitive outcomes between platform complements. The influx of late adopters to the platform causes a concave curvilinear effect of platform maturity on the

¹⁰ Gartner Says Worldwide Video Game Market to Total \$93 Billion in 2013. - <http://www.gartner.com/newsroom/id/2614915> - Last accessed August 2014.

adoption of complements. Furthermore, differences between early and late platform adopters reinforce the “natural monopoly” that superstar complements enjoy. Competition increasingly favors superstar complements as the adoption disparity between popular and less popular complements widens as platforms mature. Lastly, platform maturity strengthens the “double jeopardy” that innovative complements suffer from. Not only are late platform adopters less aware of novel complements, their risk aversion increasingly wards them off from choosing them.

3.2. Two-sided Markets

Platform owners in two-sided markets act as intermediaries between two distinct user groups: providers of complementary goods and end-users.¹¹ Platforms are tasked with creating infrastructure and designing a pricing mechanism that entices both market sides to join (Rochet & Tirole, 2003; 2006). Newspapers have to get advertisers and readers to join, shopping malls need to attract retail establishments and shoppers, and video game consoles target game developers and consumers of video games. An important feature of platform markets is the existence of indirect network effects: complementors derive value from the presence of end-users on the platform, and vice-versa (Parker & Van Alstyne, 2005). The addressable market for complements is dictated by the installed base (i.e. the cumulative number of platform adopters at a given time), whereas a platform’s appeal to end-users is in large part contingent on the variety, exclusivity and quality of the complements available on the platform (Binken & Stermersch, 2009; Corts & Lederman, 2009; Haigu & Spulber, 2014; Landsman & Stermersch, 2011; Lee, 2013). Other factors that drive platform adoption include platform quality and platform price

¹¹ Platform markets often include more than two sides and may thus be multisided (Hagiu & Wright, 2011). For sake of exposition and in line with most of extant literature, I restrict myself to platforms with two sides (Gawer, 2014).

Network effects in two-sided markets can be direct (same-side) and indirect (cross-side), and they may be either positive or negative (Eisenmann *et al.*, 2006; Gawer, 2014; Parker & Van Alstyne, 2005; Stremersch *et al.*, 2007). While end-users of a technology platform typically enjoy positive network effects (Katz & Shapiro, 1986), network effects for complementors may be both negative and positive (Eisenmann *et al.*, 2006; Wareham *et al.*, 2014). An increase in the number of complements on a platform will boost end-users' platform utility leading to higher platform adoption rates, and subsequently to larger addressable audiences for complementors. On the other hand, increases in complements on a platform can also lead to "competitive crowding," reducing complementors willingness to join the platform or their incentive to create superior value (Boudreau *et al.*, 2011; Boudreau, 2012; Stremersch *et al.*, 2007; Venkatraman & Lee, 2004). While there has been no indisputable answer to the same-side network effects puzzle for complements, early empirical work favors the "competitive crowding" hypothesis.

Platform market shares often stand in marked contrast as competition disproportionately favors the platform that manages to quickly attain a critical mass of platform users (Schilling, 1998; 1999; 2002).¹² This tipping of the market – "*the tendency of one system to pull away from its rivals in popularity once it has gained an initial edge*" (Katz & Shapiro, 1994; p. 106) – leads to nonlinear adoption rates where the slope of the platform adoption curve grows exponentially. At some point in the platform lifecycle, however, the growth rate inflects, and eventually plateaus. Drivers behind the S-shaped adoption curve for technology platforms have been extensively studied in management, marketing and economics research. Explanations are both

¹² It is for this reason that platform owners often subsidize one side in order to quickly ramp up adoption rates on the other. Some newspapers subsidize readers by giving away free newspapers to attract advertisers. Video game platform owners sell their consoles at a loss to quickly build an installed base developers can sell their games to. Mobile operating systems, on the other hand, have lowered barriers to market entry for apps developers to foster an abundant apps 'ecosystem' that will attract buyers of smartphones. Platforms derive most utility from subsidizing participants with the highest price elasticity and those whose exclusive participation in the market has the strongest impact on indirect network effects (Eisenmann *et al.*, 2006; Rysman, 2009).

supply and demand-side oriented and include exhaustion of a platform's development trajectory or displacement by a superior next generation platform (Foster, 1986; Utterback & Abernathy, 1975), demand heterogeneity, social learning, and saturation of demand (Adner, 2002; Banjeree, 1992; Bass, 1969; 2004; Bikchandani *et al.*, 1992; Rogers, 2003; Young, 2009).

3.3. Complement Adoption in Two-sided Markets

A self-evident starting point for explaining complements adoption in platform markets is indirect network effects. Increments in end-users on the platform side will lead to a temporal surge in sales on the complements side (Stremersch *et al.*, 2007). Platforms should, however, not be seen as static entities, but rather as “evolving meta-organizations” in which users' roles change and affect the pace of competition over time (Gawer, 2014; p. 124). One such change is caused by heterogeneous customer segments that self-select into the platform as it matures (Chao & Derdenger, 2013; Lee, 2013; Parker & Van Alstyne, 2005). A growing installed base, a greater variety in complements, changing platform prices, and in certain cases, enhancements to the platform, trigger a cascading effect where end-users with qualitative differences in characteristics and behavioral traits enter the platform as it matures. Using the diffusion of innovations literature as theoretical base, below I develop three arguments on how demand heterogeneity of end-users affects the adoption of complements over the platform lifecycle.

3.3.1. Demand Heterogeneity and Social Learning: A key foundation of the diffusion of innovations literature is the notion of demand heterogeneity over the product lifecycle (Rogers, 2003). Adopters of an innovation can be placed on a continuum ranging from early adopters (“innovators”) to late adopters (“laggards”). Early adopters differ from late adopters along three dimensions that Rogers (2003; p. 280) collectively defines innovativeness: “[T]he degree to

which an individual ... is relatively earlier in adopting new ideas than other members of a social system.” First, earlier adopters are more risk-seeking than are later adopters. Early adopters of a platform display “venturesomeness” by choosing a platform without having exact knowledge of the future availability of complementary goods, or whether competition will eventually favor said platform as the dominant design (Schilling 1998; 1999). Secondly, earlier adopters are more prone to independently seek information from external sources and therefore have greater innovation-specific knowledge than do later adopters. Early platform adopters are forced to base their decision of which platform to choose on its technological prowess (relative to rival platforms) rather than on the variety of complements available on the platform (Clements & Ohashi, 2005; Gretz & Basuroy, 2013). Third, early adopters are less price-sensitive than are later adopters (Golder & Tellis, 2004). To capture more price sensitive customer segments, platform owners typically lower platform prices over time.¹³

As per illustration, demand heterogeneity in the market for video games has been typically referred to as the distinction between *casual gamers* and *hardcore gamers*. More so a continuum rather than a dichotomy, casual gamers overlap with what Rogers (2003) defines as late adopters while hardcore gamers resemble the depiction of early adopters. Consider the following quote by video game theorist Jesper Juul: “The *stereotypical casual player* has a preference for positive and pleasant fictions, has played few video games, is willing to commit small amounts of time and resources toward playing video games, and dislikes difficult games.” (Juul, 2010; p. 29; emphasis in original) And: “The *stereotypical hardcore player* has a

¹³ Diffusion processes follow a normal distribution where innovativeness is partitioned in standard deviations from the average adoption time (Rogers, 2003). Similar to a platform’s lifecycle cumulative adoption follows an S-shaped curve where the mean denotes the inflection point. Rogers identifies five adopter categories: Innovators (2.5% of all adopters); early adopters (13.5%); early majority (34%); late majority (34%); and, laggards (16%). These categories are exhaustive in that they include all adopters of a given innovation, but exclude non-adopters. It is important to note that the commonly used adopter categories are a conceptual tool and that the underlying dimensions distinguishing early adopters from late adopters are, in fact, continuous.

preference for emotionally negative fictions like science fiction, vampires, fantasy and war, has played a large number of video games, will invest large amounts of time and resources toward playing video games, and enjoys difficult games.” (Juul, 2010; p. 29; emphasis in original)

Besides these differences in characteristics between early and late adopters, there also exists variation in behavior of people that adopt an innovation at different points in time. Social learning is the process by which late adopters of an innovation learn from the choices and experiences from early adopters (Banerjee, 1992; Bikhchandani *et al.*, 1992). While Rogers’ (2003) adopter profiles explain *who* adopts *when*, social learning explains *why* people adopt an innovation. People adopt an innovation once they perceive enough evidence that it is worth adopting. People’s individual characteristics determine their thresholds for sufficient evidence (Young, 2009). For example, ‘enthusiast gamers’ need less convincing to buy a game console than do ‘casual gamers’. Evidence can be broken down into two components: the accumulation of previous adopters, and the value created for earlier adopters. The accumulation of previous adopters is often easily transmittable, and it is for this reason that platform owners attempt to influence the perceived installed base and availability of complementary goods through press releases signaling forecasted and actual sales numbers (Schilling, 2003). Judging the value others derived from adopting an innovation, however, may be problematic when the pool of previous adopters consists of heterogeneous people with different preferences, or when an innovation’s use value is difficult to gauge (Munshi, 2004).

The aforementioned dynamics have important implications for the diffusion of platform complements. Without the notion of demand heterogeneity, while controlling for supply side factors including quality, competition from rival complements entering the platform, and platform substitution effects, one expects the (lagged) cumulative adoption of complements to

follow a pattern that mimics the growth curve of the installed base (i.e. sigmoid). Evolving demand heterogeneity, however, imposes two downward sloping trends on the adoption curves for platform complements. First, by virtue of their characteristics, early adopters adopt more complements than do late adopters. Early adopters are more aware of the full portfolio of complements on a platform, they are more prone to adopt complements for which the perceived quality prior to consumption is uncertain, and their lower price sensitivity will translate into more money spent (e.g. more complements adopted). Secondly, late adopters let their adoption behavior depend more strongly on the choices made by early adopters. Complements that gain popularity early in the platform lifecycle will thus enjoy extended popularity from late platform adopters that imitate early adopters' choice of complements.

These two downward sloping forces are illustrated by figure 3.1 that displays game attach rates by platform maturity for three sixth generation console video games in the United Kingdom (2000-2007). Attach rates measure the number of system adopters that own a typical complementary good released within a particular timeframe. For example, 36% of all Nintendo GameCube owners in the first 10% of the platform's lifecycle owned a typical video game released in that same time period. The attach rate drastically declined to 15% for the second decile indicating that the average game was bought by relatively fewer people. The attach rates were measured ex-post and therefore include social learning effects of late platform adopters buying video games that were released early in the platform lifecycle.

--- INSERT FIGURE 3.1 HERE ---

Complements that are released early in the platform lifecycle face an installed base of relatively few but favorable end-users, while complements that are released late face many end-

users that are more reserved and backward looking. Although the exact shape of the adoption curve depends on a platform's diffusion rate and the ratio of complements to end-users on a platform, it is expected that early in the platform lifecycle complements will benefit from increments in the installed base. Increases in platform end-users that look forward to adopting a variety of complements positively affect complements that enter the platform at the same time. As platforms mature and late adopters increasingly enter the platform, however, it is expected that the adoption of complements that also enter late falls. Late adopters only buy few complements and look back to earlier adopters for guidance in their adoption patterns. Combined, these postulations lead to the paper's main hypothesis that:

Hypothesis 1. Platform maturity will have an inverse U-shaped effect on complement adoption:

Complements launched early or late will have lower adoption rates compared to those launched at intermediate stages of the platform lifecycle.

3.3.2. The Adoption of Innovative and Superstar Complements: Platform maturity does not affect all complements equally. Obscure complements are at a disadvantage when it comes to platform end-users' purchase decisions. In his seminal book on formal theories of mass behavior, McPhee (1963) found that the larger the proportion of adopters who are unfamiliar with an alternative in a competitive market, the less likely the ones who are familiar with it are to choose it. Obscure complements' disadvantage – that many end-users are unaware, and therefore cannot choose it – is therefore amplified by the notion that platform adopters who do know of the offering tend to be well-informed of the overall competitive landscape. Informed adopters know of many alternatives, which reduces the probability of them choosing any option in particular. And, unless an obscure alternative is of superior quality, such complements are at lower risk of being adopted since well-informed platform users tend to “know better” (Ehrenberg, Goodhardt

& Barwise, 1990). This “double jeopardy” of the obscure has implications for the adoption of innovative complements in two-sided markets.¹⁴

A steady supply of innovation on the complements side creates value for the platform owner and its end-users (Gawer & Cusumano, 2014). Complementors are tasked with the strategic tradeoff of releasing novel or non-novel complements (Tschang, 2007).¹⁵ Novel complements are shrouded by uncertainty, yet they help shape the identity of a platform and may boost platform sales upon gaining popularity (Boudreau, 2012). On the other hand, novel complements are unprecedented and as such impose valuation ambiguities to end-users on the platform. By virtue of their equivocality, novel complements impose greater information needs to assess complement quality and perceived use value. It is for this reason that the adoption of novel complements is disproportionately affected by the evolving composition of the installed base. High information needs are particularly problematic for late adopters that tend to be aware of only a small subset of the competitive offerings available in a market. And when they are aware, late adopters’ risk aversion will direct them to favor non-novel complements instead. The paper’s second hypothesis therefore is:

Hypothesis 2. As platforms mature, the adoption disparity between novel and non-novel complements will increase: Novel complements’ adoption rates will increasingly fall behind those of non-novel complements.

¹⁴ Double jeopardy is recognized by consumer behavior theorists as a “law-like” occurrence in competitive markets (e.g. Ehrenberg *et al.*, 1990; Ehrenberg & Goodhardt, 2002).

¹⁵ Video game developers are faced with the tension between producing games that are based on new intellectual property (IP) or derivatives of existing video franchises (“sequels”) and external media adaptations such as Hollywood films. “Newspaper of record” *The New York Times* largely relies on coverage generated by in-house journalists while the free newspaper *Metro* relies on licensing externally generated content from news agencies such as Reuters.

On the other hand, the most popular complements on a platform not only enjoy the greatest absolute popularity across different adopter categories, they also enjoy the greatest relative popularity from adopters that are ill-informed and least likely to know of many complements (McPhee, 1963). Complements that enjoy the greatest exposure are at higher “risk” of being discovered by the entire population of platform end-users. However, due to the qualitative differences that exist across adopter categories, complements with low exposure tend to only be discovered by platform adopters that are prone to seek information about many alternatives (i.e. early adopters). Furthermore, once a complement gains a slight competitive advantage, social learning increasingly puts ill-informed adopters (i.e. later adopters) at risk of discovering said complement at the cost of alternatives in the marketplace. MCPhee (1963) called this natural tendency towards a disproportional dominance of the popular, “natural monopoly.”

Superstar complements are complements of high quality and popularity, and are paramount to a platform’s success (Lee, 2013; Stremersch *et al.*, 2007). In their study of superstar software in the US market for console video games, Binken & Stremersch (2009) found that high quality video games that sell in excess of one million units boost platform sales by 14%. Similarly, Lee (2013) finds that without the presence of a top-selling video game on a platform, video game console sales would drop by as much as 700,000 units. The market for complements is “hit-driven” and complements popularity follows a skewed distribution where ordered ranks decline with exponential decay (Boudreau, 2012). This fact is well-illustrated by the example of *Grand Theft Auto V*. The hit game sold more copies in its opening week in the UK than the opening weeks for the six subsequent most popular franchises combined.¹⁶ My third postulation is that

¹⁶ GTA V UK sales bigger than Battlefield, FIFA, Call of Duty, Batman, Pokemon and Assassin's Creed combined. <http://www.mcvuk.com/news/read/gta-v-uk-sales-bigger-than-battlefield-call-of-duty-batman-pokemon-and-assassin-s-creed-combined/0124337> - Last accessed August 2014.

the skewness in the rent distribution between popular and less popular complements is contingent on the changing audience composition on a platform. More specifically, as more late adopters enter the platform, the natural monopoly that popular complements enjoy becomes stronger. By virtue of late adopters' poor knowledge of the market, linear increments in exposure will increasingly lead to disproportionate increments in complement adoption as platforms mature. My third and final hypothesis, therefore, is that:

Hypothesis 3. As platforms mature, the adoption disparity between popular and non-popular complements will increase: Popular complements' adoption rates will increasingly surpass those of non-popular complements.

3.3.3. Synthesis: The notion of demand heterogeneity adds nuance to our understanding of indirect network effects in two-sided markets. As platforms mature, the installed base grows and changes composition over time (Chao & Derdenger, 2013; Lee, 2013; Parker & Van Alstyne, 2005). Late platform adopters are qualitatively different from early platform adopters. Differences in characteristics and behavior affect the adoption of complements over the platform lifecycle. Increases in platform maturity equate a larger addressable market that augments complementors' potential diffusion rates through indirect network effects. Late platform adopters, however, adopt fewer complements and are backward looking in their adoption pattern, mimicking earlier adopters' choices. This underlying demand heterogeneity has three implications for the adoption of complements that are launched across the platform lifecycle: (1) platform maturity has a concave curvilinear effect on complements adoption; (2) the adoption disparity between innovative complements and non-novel complements increases as platforms mature; and (3), the adoption disparity between superstar complements and less popular complements also widens as platforms mature.

3.4. Research Setting and Methodology

"I understand the manufacturers don't want [new platforms] too often because it's expensive, but it's important for the entire industry to have new consoles because it helps creativity. It's a lot less risky for us to create new IPs when we're in the beginning of a new generation."

Yves Guillemot, CEO Ubisoft¹⁷

3.4.1. The Market for Console Video Games in the United Kingdom (2000-2007): The console video games industry includes platform owners that facilitate a technological infrastructure for video game publishers to release their games on, and end-users who must adopt a given console in order to enjoy the video games released on said platform. Platform owners receive a royalty payment from every game sold in exchange for the financial risk taken towards designing and commercializing the platform. Platform owners often sell their consoles at a loss to increase end-user adoption early on in the platform's lifecycle. These losses are subsidized by the royalty payments from independent game publishers and via internally developed game sales. While the majority of video games on a platform are produced and commercialized by independent third party publishers, platform owners do engage in some first-party game development.¹⁸ Given the substantive investments and long recoupment trajectories, platform owners typically release new platforms only every 5 to 8 years.

I focus my attention on the sixth generation video game consoles in the United Kingdom. The UK market for video games is disproportionate to the country's size in terms of cultural and economic relevance (Johns, 2006). In 2010, the UK market for video game consoles represented

¹⁷ Ubisoft's Guillemot: New Consoles are Overdue. http://www.gamasutra.com/view/news/174498/Ubisofts_Guillemot_New_consoles_are_overdue.php - Last accessed April 2014.

¹⁸ First-party video game releases account for approximately 9% of all games in the data used for this study.

about 20% of the global market (IDG, 2011). I chose the sixth generation as it was the most recent generation for which data on a full platform lifecycle was available at the time of data collection. Rival platforms in this generation are Sony's PlayStation 2, Microsoft's Xbox and Nintendo's GameCube. Sony was the first to enter the sixth generation in November 2000 followed by Microsoft and Nintendo in March and May 2002, respectively. Sony's PlayStation 2 was the dominant platform in this generation with over 9 million units sold in the UK. By the end of the sixth generation Sony dominated the market with 74% market-share followed by Microsoft (17%) and Nintendo (9%), respectively. The seventh generation video game consoles commenced with the launch of Microsoft's Xbox 360 in December 2005 (see table 3.1).

--- INSERT TABLE 3.1 HERE ---

Among the most popular franchises of the sixth generation video games in the UK are *Grand Theft Auto* (Take 2 Interactive), *FIFA* (Electronic Arts), *Need For Speed* (Electronic Arts), *Halo* (Microsoft), and *Super Mario* (Nintendo). The most popular game by cumulative units sold was *Grand Theft Auto: San Andreas*, which was released as a timed exclusive release for the PlayStation 2 in November 2004 and sold in excess of 2.3 million units. Highly innovative games were received with mixed reactions. Nintendo successfully launched its new intellectual property *Pikmin* early on in the lifecycle of its floundering GameCube platform (June 2002). The real time strategy game sold nearly 70,000 units and received rave expert evaluations averaging 89/100. The now defunct THQ however, released *Psychonauts*, an innovative game in the popular platform genre, close to the end of the PlayStation 2 lifecycle (February 2006). The game sold a mere 12,000 units despite rave expert scores averaging 88/100.

3.4.2. Data and Measures: I built a novel and comprehensive dataset of sell-through data for 2,921 video games released in the UK. Data was collected and combined from multiple primary and secondary sources. Video game and console sell-through data come from a series of proprietary databases provided by one of the platform owners. These datasets include information on video games' release date, average selling price, genre, and publisher identity. Quality measures were obtained from online review aggregation database Metacritic.com/games. Information on game innovativeness was hand-collected. Data on instrumental variables come from the US Bureau of Labor Statistics. The comprehensive dataset allows me to run a number of specifications ranging from instrumental variable estimators (2SLS) to game fixed effects specifications and propensity score matching techniques. These more elaborate techniques allow me to address some of the issues that exist around endogenous platform entry by complements. Table two provides an overview of the study's main variables and their respective units of analysis.

--- INSERT TABLE 3.2 HERE ---

3.4.3. Dependent Variable: Complement adoption is operationalized as a video game's cumulative unit sales. *Game unit sales* data include point-of-sale transactions for approximately 90% of all retail transactions in the UK between November 2000 and November 2007, online retailers included. Data on game sales are complete until January 2012. Given that video games typically have very short product lifecycles –most games sell the bulk of their units in the first three months (Binken & Stremersch, 2009, Tschang, 2007)– I am not concerned with structural biases caused by unintentional right censoring of the unit sales measure for games released near the tail-end of the available data. The data are comprehensive in that all console video games released in the UK are included. It is not uncommon for publishers to multi-home, or to launch

the same video game on multiple platforms at the same time (Landsman & Stremersch, 2011). By measuring unit sales at the platform level I achieve a degree of granularity that allows me to zoom in on the effect of a given platform on game sales rather than at the industry or generation level. Nevertheless, I exploit the subsample of games that do multi-home for a game fixed-effects estimation to control for unobserved heterogeneity between games released at different points in the platform lifecycle. To fit a normal distribution I take the natural log-transformation.

3.4.4. Main Effects: The study's primary focus is the effect of *platform maturity* on complement adoption. In order to facilitate a straightforward comparison between the three platforms' installed bases, I compute a normalized measure of platform maturity at time t such that:

$$Platform\ Maturity_{jt} = \frac{Installed\ Base_{jt}}{Installed\ Base_j}$$

The numerator measures the number of platform adopters on platform j in month t of a focal game's release. The denominator measures the cumulative number of platform adopters on platform j at the end of the platform's lifecycle (Stremersch *et al.*, 2007). Following previous work focusing on two-sided markets in the console video game industry, I denote the end of a console's lifecycle when monthly platform sales in the UK drop below 1,000 units, or when I observe a month without any game introductions at the platform level (Binken & Stremersch, 2009; Cennamo & Santalo, 2013; Landsman & Stremersch, 2011).¹⁹ Parsimonious comparison between competing platforms aside, using what is essentially a percentage-based measure has the additional advantage of linearizing the S-shaped platform adoption curve. Linearization allows

¹⁹ Note that in their study of the US console video game industry in the same timeframe Binken & Stremersch (2009) and Landsman & Stremersch (2011) use a threshold of 5,000 consoles sold to lineate the end of a console's lifecycle. Market analysis firm IDG (2011) estimates that the UK market for video game consoles in 2010 was approximately 20% of the US market, hence the threshold of 1,000 units. Neither of the two criteria is fully met for the PlayStation 2 by the end of the available data on hardware sales (November 2007). This forces me to right-truncate PlayStation 2's lifecycle which may introduce an upward bias in the results.

for a more straightforward interpretation of *platform maturity*'s effect on game sales. To test for the hypothesized curvilinear effect I include the squared term.

Hypothesis 2 tests the differential effect of platform maturity on novel complements' and non-novel complements' adoption. In the market for video games, novel games are a clearly demarcated and distinct product category. Games that are based on an entirely new intellectual property (IP) –observations that are not adaptations of external media (e.g. motion pictures or TV series) and are not a derivative or a sequel of an existing video game franchise (Tschang, 2007)- are labelled as novel complements. The aforementioned *Pikmin* and *Psychonauts* are telling examples of games that are based on new IP. Indicator data were hand-collected. Two graduate students and an industry expert consulted video games' box covers and other online sources to understand if a video game was based on a new intellectual property. Data were distributed among raters with some overlap to calculate inter-rater reliability kappas. The obtained kappa value ($\kappa = 0.64$) is 'good' (Fleiss, 1971), or 'substantial' (Landis & Koch, 1977).

--- INSERT FIGURE 3.2 HERE ---

New IP is a binary variable that takes the value of 1 if a video game is based on a new IP and 0 otherwise. 29% of all video games in the sample are based on new IP. This statistic corresponds with generally accepted statistics of non-imitative or really new innovations in a market (Kleinschmidt & Cooper, 1991). Figure 3.2 displays the distribution of video game introductions per platform and the ratio of new IP introductions by platform maturity.²⁰ The figure illustrates that, across different levels of platform maturity, there is sufficient variance in

²⁰ The supply of video games is disproportionate to the growth of the installed base towards the tail-end of the platform lifecycle. Games publishers are myopic to a slowing down of a growing installed base: Even when the rate of new platform adopters tapers, games publishers keep releasing new games to exploit the existing installed base. This observation is consistent with Clements & Ohashi (2005) who study the US video game industry (1994-2002).

terms of the number of games entering each platform as well as the ratio of video games that are based on new intellectual property. In the robustness testing section I address concerns of unobserved heterogeneity between novel and non-novel games released at different points in a video game console's lifecycle.

3.4.5. Controls: Given the practical and theoretical relevance of network effects in platform markets, I test for the existence of direct and indirect network effects on video games' unit sales. *Platform sales* measures the number of consoles sold at the platform level in month t_j of a focal game's release. In order to control for reversed causality I introduce a one month lag where I enter 0 consoles sold in month $t_j = 0$. To fit a normal distribution I take the log-transformation which causes 65 dropped observations in month $t_j = 0$. *Games entry* controls for same-side –or, direct network- effects on video games' unit sales. *Games entry* counts the number of video games entering a platform in month t_j at the time of a focal game's release, excluding the focal game. Here too, to I control for reversed causality by introducing a one month lag. The joint inclusion of rival games entering the platform and the number of consoles sold controls for the ratio of complements to platform end-users in a given month.

At the game level, I control for a video game's quality and for its inflation corrected average retail *selling price*. Video game quality measures were obtained from the video games section of review aggregation database Metacritic.com. I collected the average review scores in addition to the number of reviews at the platform-game level for both expert and user reviews. I use these data to compute a combined average quality score for each game. To obtain the *game quality* measure, I multiply and add up the average expert and user review scores with their

respective number of reviews and divide this by the total number of review scores.²¹ In accordance with Metacritic’s grading scheme, *game quality* is an indicator variable that takes the value of 1 if the quality score for a game is equal to or above 75 –including quality scores that are “generally favorable” and games that achieved “universal acclaim”.²² In the robustness testing section I experiment with a continuous measure of the quality variable.

Platform substitution expectedly not only affects the adoption of the focal platform, but equally so the adoption of complements that are released for the focal platform. I control for the introduction of a *next generation platform* as this may cause migration of current platform adopters to the new platform, thus negatively affecting a game’s unit sales. *Next generation platform* takes the value of 1 in months t_j where the platform owner of the focal game introduced a next generation video game console. There are nine months where the PlayStation 2 co-existed alongside the PlayStation 3, fourteen months where the Xbox co-existed alongside the Xbox 360, and no months in which the GameCube co-existed alongside its successor Nintendo Wii. It should be noted that the immensely popular Nintendo Wii console that was released in December 2006 co-existed for one month alongside the Microsoft Xbox and for twelve months alongside the PlayStation 2. The *next generation platform* dummies may therefore be picking up some of the variation caused by early cross-platform migration to Nintendo’s Wii console.

To control for systematic variation in consumer preferences for heterogeneous product categories, I include game genre fixed effects.²³ Structural variation in game sales may be further affected by differences at the publisher and platform levels. In markets for entertainment goods,

²¹ For example, *Pikmin* (Nintendo) received 39 expert scores averaging 89, and 42 user reviews averaging 87 on Metacritic. The quality measure for this game is $87.96 ((39 * 89 + 42 * 87) / (39 + 42))$.

²² How We Create the Metascore Magic. <http://www.metacritic.com/about-metascores> - Last accessed July 2014.

²³ There are 15 genres in the data, these are: action (omitted), fighting, graphic-adventure, music, non-game, platform, puzzle, racing, real game, role playing game, shooter, simulation, skateboarding, sports, and war.

publishers' marketing capabilities, product portfolios, and their relationships with gatekeepers such as platform owners are known to induce variance in product performance (Caves, 2000; Hirsch, 1972; 2000). I include 90 firm fixed effects for every publisher in the dataset. Time invariant differences at the platform level may also structurally affect game sales. One could think of hardware quality in the form of processor speed, or the functionality of software development kits. Consequently, I include two platform fixed effects with Sony's PlayStation 2 as the omitted category. Lastly, the video game industry is characterized by strong seasonality as many games are released in the weeks leading up to Christmas. To control for seasonality I include eleven calendar month fixed effects where January is the omitted category. High colinearity between the progression of time and the *platform maturity* measure prevents me from including year fixed effects. I address this potential concern in the robustness testing section by including an economic macro-trend in the econometric specifications.

3.4.6. Endogeneity: Previous studies raised concerns that *Games entry* may be endogenous, i.e. correlated with the error term (Clements & Ohashi, 2005; Corts & Lederman, 2009; Dubé *et al.*, 2010; Gretz & Basuroy, 2013). The error term captures unobserved variation in game sales that may be correlated with the number of games entering the platform. The assumption is that producers of console video games are more prone to enter a platform (or, to do so with greater intensity) after observing high diffusion rates for games on said platform. After all, if “success-breeds-success,” it pays off to enter the platform with the highest performing games. To control for the potential bias introduced by such endogeneity, I seek instrumental variables that are correlated with the endogenous covariates but uncorrelated with the error term.

I follow Dubé *et al.* (2010) and Gretz & Basuroy (2013) in their approach of including a cost-side instrument for *Games entry*. I exploit the fact that nearly half of the games (46%) are

produced in the United States.²⁴ As a proxy for the cost of producing games I obtain data on Producer Price Indexes (PPI) for video game publishing in the US from the Bureau of Labor Statistics (BLS). Anecdotal evidence has it that production cycles were approximately one year for developing and publishing a video game for sixth generation game consoles. Hence, I introduce a one year lag in *PPI games publishing*. The assumption is that increases in the cost of making video games in $t_j - 13$ negatively affect *Games entry* rates for video games in $t_j - 1$. It is reasonable to assume that the cost of making games in the US thirteen months ago does not affect a UK-based consumer's decision as of whether or not to adopt a game today.

I use Wu's (1973) test of endogeneity to rule out the possibility that the potentially endogenous covariate is in fact exogenous. I reject the null hypothesis that *Games entry* is exogenous as the F-statistic of 6.67 is statistically significant ($p < 0.01$). In the robustness testing section I experiment with different time lags. I also experiment with including *platform age*, its squared term, and their interaction with the instrumental variable to isolate platform specific effects. However, under these specifications I fail to accept the null hypothesis that the first stage models are correctly identified. Appendix A reports first stage results and offers a more detailed diagnosis of the first stage estimations.²⁵

²⁴ Japan is the second biggest hub for video game production accounting for 20% of all video games, followed by the UK, accounting for 19% of all games produced.

²⁵ In similar vein, some have further argued that *platform sales* is endogenous (Clements & Ohashi, 2005; Corts & Lederman, 2009; Dubé et al., 2010). *Platform sales* is in large part determined by the retail price strategically set by the platform owner, which is further affected by various cost- and demand-side factors including the popularity of the platform and the cost of producing consoles (Clements & Ohashi, 2005). A valid cost-side instrument is the currency exchange rate between the country in which a console was produced and the country of a focal game's release (Clements & Ohashi, 2005; Corts & Lederman, 2009). Since 77% of the consoles sales in the data were produced in Japan, I use the currency conversion rate between the Japanese Yen and the Great Britain Pound as instrument for platform sales. As the Yen grows stronger vis-à-vis the British pound, platform owners are forced to charge higher prices for their platforms. Notwithstanding instrument exogeneity and validity, after applying Wu's (1973) test of endogeneity I fail to reject that platform sales is exogenous to the cumulative unit sales of video games released in the following month ($F = 0.09$). Since two-stage least squares comes at the cost of being

--- INSERT TABLE 3.3 HERE ---

Table 3.3 lists descriptive statistics and Pearson correlation coefficients for the study's covariates. The final sample for estimation comprises 2,855 observations released over 189 console-months.

3.4.7. Analytical Approach: Empirical analyses rely on reduced form regressions. To understand the effect of platform maturity on video games' unit sales I estimate variations on the following equation

$$y_1 = z_1\delta_1 + a_1y_2 + u_1$$

$$y_2 = z\pi_2 + v_2$$

Where y_1 is the dependent variable (*game unit sales* for a focal game at the platform level), $z_1\delta_1$ represents the full vector of exogenous covariates, y_2 is the endogenous covariate (*Games entry*), and u_1 is the error term. y_2 is a function of all exogenous covariates plus the excluded instrument z (*PPI games publishing*). I use two-stage least squares (2SLS) for obtaining the predicted values for \hat{y}_2 which are then used in the second stage instead of y_2 . I thus re-write the equation as:

$$y_1 = z_1\delta_1 + a_1\hat{y}_2 + u_1$$

To identify the performance disparity between popular and less popular video games I use weighted least absolute deviation estimators, or quantile regressions (Koenker & Bassett, 1978). Quantile regressions are apt estimators when the researcher is interested in how independent variables affect various points in the distribution of the dependent variable. Recent

potentially biased and less efficient than OLS (Woolridge, 2002), I proceed with the more efficient just-identified case where only Games entry is instrumented.

studies in strategy have used quantile regressions to estimate effects on observations residing in the tail-end of the distribution (Boudreau *et al.*, 2011; Elberse & Oberholzer-Gee, 2008). Estimating and comparing coefficients for observations in the lower quantiles and higher quantiles of the dependent variable allows me to make inferences about the effect of *platform maturity* on the sales disparity between popular and non-popular video games. I report outcomes to estimations $Quant_{\tau}$, where $\tau = 25$ estimates non-popular games, $\tau = 75$ estimates popular, or superstar, video games, and $\tau = 50$ (median) is used as a reference.

Recent work in econometrics addressed the issue of endogeneity in quantile regression models. Assuming that $D(u_1 + v_2|z)$ is symmetrically distributed, one can use Ma & Koenker's (2006) Control Function Quantile Regression (CFQR) to control for unobserved endogeneity in *Games entry*, where

$$u_1 = \rho_1 v_2 + e_1$$

and e_1 given z has a symmetric distribution. Since $Quant_{\tau}(v_2|z) = 0$, I follow Ma & Koenker (2006) in their estimation of the first stage using a least absolute deviations quantile regression where $\tau_1 = \tau_2 = \tau$. I can then obtain the residuals \hat{v}_{i2} as a function of $\hat{v}_2 = y_2 - z\hat{\pi}_2$ which are added together with their interaction with the endogenous variable y_2 to the second-stage least absolute deviations estimation. Hence, for the quantile estimations I write

$$Quant_{\tau}(y_1|z_1, y_2, \hat{v}_2)$$

To apprehend the problem of incorrectly computed standard errors from manually computed control functions, I use the bootstrapping technique to compute standard errors in both the first and second stage equation (Woolridge, 2007). For all quantile estimations I use 100 draws for computing the standard errors.

3.5. Results

3.5.1. Main Models: Models 1-6 in table 3.4 estimate the baseline model using OLS. I begin by estimating the effect of the various fixed effects on game unit sales in model 1. Model 2 adds control variables and models 3-6 add independent variables following a nested linear approach. Model 7 re-estimates model 6 using Two Stage Least Squares where *Games entry* is instrumented with *PPI games publishing*. All models report heteroskedasticity robust standard errors in parentheses.

--- INSERT TABLE 3.4 HERE ---

Let the instrumental variable estimation (model 7) inform our main findings. Hypothesis 1 postulates an inverse U-shaped effect of *platform maturity* on games' cumulative unit sales. Hypothesis 1 is supported as we observe a positive linear effect from *platform maturity* (3.88; $p < 0.01$) and a negative non-linear effect from *platform maturity*² (-2.52; $p < 0.01$) on game sales. Early on in a video game console's lifecycle, increases in platform maturity positively affect games' unit sales as surges in platform adoption create a larger addressable market for video games. However, after a certain point in the platform's lifecycle, the positive effect of platform maturity on games' unit sales is depressed as more late adopters enter the platform. Figure 3.3 plots *game sales*' fitted average values within every decile of *platform maturity*. The negative effect of *platform maturity* towards the tail end of the platform lifecycle is stronger than the positive effect early in the lifecycle. This finding may be explained by (1) early platform adopters' lower price sensitivity leading to more game purchases, (2) a higher ratio of games-to-platform adopters at higher levels of platform maturity (see figure 3.2), or (3) late adopters'

imitative behavior resulting in greater game sales for video games popular with early platform adopters.

--- INSERT FIGURE 3.3 HERE ---

The instrumental variable estimator lends support to the presence of indirect network effects from temporal surges in platform sales on video games' adoption rates. We observe a positive effect from increases in *platform sales* in $t_j - 1$ on *game unit sales* in t_j in model 7 (0.46; $p < 0.01$). Exponentiating the coefficient shows that a ten percent increase in platform sales in a given month leads to a nearly five percent (4.58%) increase in average cumulative unit sales for a video game released in the subsequent month. This finding can be explained by the fact that new platform adopters need games in order to enjoy their console purchases.

We observe a negative direct network effect from rival video games entering the platform in $t_j - 1$ on games' average unit sales in t_j . Model 7 states a negative effect of *Games entry* on game sales (-0.09; $p < 0.05$). This result implies an almost nine percent (8.60%) drop in games' unit sales following one additional video game entering the platform in month $t_j - 1$. This result favors the "competitive crowding" hypothesis of direct network effects in the setting of sixth generation console video games. Instrumenting *Games entry* with *PPI Games Publishing* has important implications for the reported results. In the exogenous models I find a positive effect from *Games entry* on unit sales (0.01; $p < 0.10$). Not controlling for the correlation between *Games entry* and the error term –potentially fostered by publishers' anticipation of *success-breeds-success* effects- induces a positive bias on the covariate's coefficient in models 4-6.

Quality has a positive effect on games' unit sales (0.34; $p < 0.01$). Video games with an average combined expert and user review score of 75 or higher sell 40.49% more units compared

to those games that fall below the quality threshold. The average inflation corrected retail price has a positive effect on games' unit sales (1.31; $p < 0.01$). A ten percent increase in retail price leads to a 13.30% increase in game sales. This counterintuitive finding may be caused by unobserved heterogeneity in publishers' pricing strategies. Publishers who fail to gain traction in the marketplace are known to lower their prices in an attempt to ramp up demand. I devise various alternative specifications in the robustness testing section to deal with this concern.

Lastly, we observe a strong effect from the introduction of a next generation platform on game sales (-0.98; $p < 0.01$). The migration of current platform adopters to the next generation platform significantly hurts game sales. Video games introduced in months where platform owners Sony and Microsoft have launched their next generation platforms sell 62.47% fewer units compared to those games introduced before this period. It should be noted that the effect of platform substitution is four times stronger for novel games compared to non-novel games (see table 3.5, further explained below). Early platform adopters that have a stronger preference for novel video games than do late platform adopters are among the first to migrate from current generation platforms to the next generation.

3.5.2. Innovative Video Games: Model 7 in table 3.4 reports a negative correlation between games based on new intellectual property and their cumulative unit sales (-0.30; $p < 0.01$). All else equal, video games based on new intellectual properties sell 25.92% fewer units compared to non-novel games. Controlling for quality and price, games that are based on new IP impose substantively greater uncertainty to platform adopters. This section assesses the effect of *platform maturity* on the sales disparity between novel and non-novel games. I replicate model 7 using a split-sample analysis of games that are based on new IP and those that are not. I report results from both OLS and 2SLS estimations in table 3.5. While the different estimators are

directionally consistent for the variables of interest, I let the instrumental variable estimations (2SLS) inform our main findings.

--- INSERT TABLE 3.5 HERE ---

Hypothesis 2 postulates a widening of the adoption disparity between novel and non-novel games' as more late adopters enter the platform. The coefficients in table 3.5 show that the curvature for *platform maturity* is stronger for games based on new IP's than those that are not. These results suggest that novel games benefit more strongly from adopters entering the platform early in the platform lifecycle (*novel*: 7.29; $p < 0.05$; *non-novel*: 2.81; $p < 0.05$). Novel games however, are also more severely harmed by adopters entering the platform at later stages in the platform lifecycle. *Platform maturity*² more strongly impacts novel games' unit sales compared to non-novel games (*novel*: -4.98; $p < 0.01$; *non-novel*: -1.80; $p < 0.05$). Taken together, these results lend support to hypothesis 2.

--- INSERT FIGURE 3.4 HERE ---

To further validate this finding I test the joint null-hypothesis that the difference in the *platform maturity* and *platform maturity*² coefficients between the two subsamples is equal to zero. Wald-tests following a seemingly unrelated regression (SUR) show that there is indeed a difference between the effect of *platform maturity* ($\chi^2 = 3.75$; $p < 0.10$) and *platform maturity*² ($\chi^2 = 4.98$; $p < 0.05$) on unit sales between both subsamples. These results imply that games based on *new IP* sell marginally better when released early in on a platform's lifecycle, while later on *new IP* sells considerably worse when compared to non-novel games. Figure 3.4 graphically depicts this finding and shows that halfway through a console's lifecycle, the sales disparity between novel and non-novel games widens at the cost of novel games. The difference

between the predicted unit sales for novel and non-novel video games is significant for 1,605 observations (from 50% platform maturity onward).

3.5.3. Superstar Video Games: In the final set of regression models I compare both tails in the distribution of the dependent variable to assess if the sales disparity between non-popular and popular video games widens as platforms mature. Using a manually computed CFQR, I estimate all covariates on $\tau = 25$ (non-popular games), $\tau = 75$ (popular games), and $\tau = 50$ (the median) as reference. Table 3.6 reports the outcomes to the control function quantile regressions as well as a series of simultaneous quantile regressions (SQR) where all variables are assumed to be exogenous. As before, let the instrumental variable estimator (CFQR) inform our main findings.²⁶

--- INSERT TABLE 3.6 HERE ---

Hypothesis 3 posits that as more late adopters enter a platform, the adoption disparity between popular and non-popular complements amplifies in favor of the popular. For non-popular video games ($\tau = 25$), *platform maturity* has a downward sloping curvilinear effect as *platform maturity*² significantly affects games' unit sales (-1.89; $p < 0.01$). As platforms mature, video games that reside in the left tail of the distribution sell exponentially fewer units. Model Q75 (CFQR) in table 3.6 reports a positive effect of *platform maturity* on game sales (5.02; $p < 0.01$) and a negative effect of *platform maturity*² (-2.60; $p < 0.01$) for popular games. The interpretation of this finding is comparable to the models relating to hypothesis 1: at low levels

²⁶ The models fail to reach convergence with the full vector of covariates. In order to reach convergence I create firm-portfolio category dummies that are calculated at the year level. For each observation I count the number of games released at the year level for the publishing firm. I use the following buckets as publisher portfolio fixed effects: fewer than 10 games released (n=722; omitted); between 10 and 20 games released (n=803); between 20 and 30 games released (n=456); between 30 and 40 games released (n=568); more than 40 games released (n=372).

of *platform maturity* increments in the installed base have a positive effect on popular games' cumulative unit sales, while this effect becomes negative for high levels of *platform maturity*.

--- INSERT FIGURE 3.5 HERE ---

The joint implication of these findings is that early in a platform's lifecycle, the sales disparity between superstar games and less popular titles is fairly stable. As more late adopters enter the platform however, platform end-users increasingly congregate around a few key titles at the cost of other games in the market: Popular video games reinforce their "natural monopoly" at the cost of the less popular games. Taken together, these results lend support to hypothesis 3. Graphical evidence for hypothesis 3 is given in figure 3.5. The adoption disparity between popular and non-popular video games steadily increases from the 4th decile of a platform's lifecycle, and this disparity is significant for 2355 observations.

3.5.4. Robustness Testing and Alternative Explanations: One may be concerned about unobserved heterogeneity between games released at different points in a platform's lifecycle. Publishers may strategically time the release of different *types* of video games anticipating higher sales volumes. Furthermore, as the costs for acquiring System Development Kits (SDK's) fall over time, producers with substantially smaller production budgets –and subsequently, lower sales thresholds- may seize the opportunity to enter a platform late in the platform lifecycle. To apprehend these concerns, I restrict myself to games released on multiple platforms to run a within game effects regression. This allows me to isolate the effect of *platform maturity* on games' unit sales from game- and publisher-level factors. Due to limited variance in the timing between releases of games that multi-home (i.e. most games that multi-home are released on

multiple platforms simultaneously (Corts & Lederman, 2009)), it is reasonable to expect that *platform maturity* may lose some of its statistical power.

--- INSERT TABLE 3.7 HERE ---

Table 3.7 reports the outcome of a fixed-effects 2SLS analysis for the 1492 video games that multi-home. I find a positive linear effect of *platform maturity* (1.67; $p < 0.10$) and a negative curvilinear effect of *platform maturity*² (-2.80; $p < 0.01$) on games' unit sales, further validating the study's main hypothesis. It should be noted that in the game-fixed effects specification, *game selling price* changes direction compared to the study's main models. All else equal, higher inflation corrected average retail prices have a negative effect on game unit sales (*game selling price*: -0.61; $p < 0.01$).

To further eliminate potential biases caused by heterogeneous pricing policies I re-estimate all models with an alternative dependent variable. Games' average selling prices could be endogenously determined as a function of their market performance over time. Publishers of initially unsuccessful games may lower their prices in an attempt to ramp up demand. I circumvent this concern by using the log-transformation of *cumulative revenues* (in GBP) as alternative dependent variable while dropping game selling price from the models. Results from this robustness test are identical to those reported in the main analyses.

One may also be concerned with unobserved heterogeneity between games that are based on *new IP* and those that are not. Publishers that successfully establish new intellectual properties may deploy an exploitation strategy by releasing sequels based on their successful franchises, leaving the production of novel games to less shrewd producers. To assess the average treatment effect (ATE) for games that are based on *new IP* vis-à-vis non-novel games, I

run a splined-sample matched pair regression. Using propensity-scores based on nearest neighbor matching, I link each *new IP* video game with their closest non-novel counterpart within each decile of *platform maturity*. I base the matching equation on the following covariates: *platform maturity*; *game quality*; *game selling price*; *platform sales*; *games entry*; and *next generation platform*. This robustness test aids in reducing endogenous differences between innovative and non-novel games released within the same period in a console's lifecycle. Regression coefficients for the full sample and splined subsamples are reported in table 3.8 and plotted in figure 3.6.

--- INSERT TABLE 3.8 HERE ---

--- INSERT FIGURE 3.6 HERE ---

The overall treatment effect for the full sample is -0.55 ($p < 0.01$). On average, games that are based on new IP sell 42.31% fewer units compared to their nearest non-novel neighbors. Matching thus amplifies the negative effect that *new IP* has on games' unit sales compared to the 2SLS model as reported in table 3.4. As illustrated by figure 3.5 however, the ATE grows from 0.16 (*n.s.*) in the first decile of *platform maturity* to -1.00 ($p < 0.01$) in the last decile of *platform maturity*. In line with hypothesis 2, these results can be interpreted that as platforms mature, games based on *new IP* enjoy increasingly lower unit sales in comparison to their non-novel counterparts. Notwithstanding the fact that games that are based on *new IP* tend to be of marginally higher quality (0.19; $p < 0.10$), I find that as platforms mature, publishers increasingly shy away from releasing new IP's (*Platform maturity*: -1.03; $p < 0.01$).

I assess the robustness of the results to alternative measures for the *game quality* variable. Some games did not receive any review scores ($n=810$). Since critics' attention for entertainment

goods is allocated non-randomly (Hsu, 2006), one may be concerned with potential biases caused by not capturing this variance with the current quality indicator. I re-estimate the models reported in the main results section with an additional indicator variable that takes the value of 1 if a video game did not receive a single review score, and 0 otherwise. This variable adds nuance to the interpretation of the results by making the distinction between games with positive review scores, games that did not receive any review scores, and all other games. The coefficient for *no quality* is not significant (-0.09; *n.s.*) and its inclusion does not structurally alter the results in any given way (*Game quality*: 0.32; $p < 0.01$). In addition, I re-estimate the models with the raw average quality score using the restricted sample of games that received at least one review score, at the risk of obtaining biased results due to selection issues. Across all models I obtain results that are consistent with the findings reported above.

Additionally, I take two precautionary steps to rule out issues of simultaneity and spurious correlations. First, I run models where I take different lags and leads for the *Games entry* and *platform sales* measures to assess if simultaneity is of any concern. *Games entry* loses significance and changes direction when lagging the variable by two platform months or by leading it by one month. *Platform sales* remains positively correlated with *game unit sales* when lagged by an additional platform month or leading it by one month. However, the strength of the effect weakens from (0.47; $p < 0.01$) in $t_j - 1$ to (0.32; $p < 0.01$) in $t_j - 2$ and $t_j + 1$.

Finally, to isolate the effect of *platform maturity* from macro-economic trends on consumer spending, I rerun all models including the annual growth rate of UK's Gross Domestic Product (GDP). Inclusion of this variable does not change any of the outcomes.

3.6. Discussion

This paper studied the adoption of platform complements in two-sided markets. The paper's main proposition was that a shifting composition of end-users on the platform affects the adoption of complements. Analyzing a dataset of 2,855 console video games, I obtained the following results. There exists a concave curvilinear effect of platform maturity on complement sales. As the number of late platform adopters increases, the positive effect of indirect network effects is mitigated by differences in late adopters' characteristics and behavior. Moreover, these differences do not affect all *types* of complements equally. First, late adopters increasingly shy away from choosing innovative complements in favor of non-novel ones. Platform maturity thus amplifies the sales disparity between innovative and non-novel complements. Secondly, late adopters increasingly congregate around superstar complements amplifying the skewness between popular and less popular complements on the platform.

Two auxiliary findings are that there exist positive indirect network effects and negative same side network effects in the market for console video games. An additional game entering the platform has a negative effect on cumulative unit sales for games launched in the subsequent month. The latter result adds support to the "competitive crowding" hypothesis of direct network effects for complements in platform markets (Boudreau, 2012; Wareham *et al.*, 2014). The finding is consistent with Venkatraman and Lee (2004) who conclude that video game developers are less likely to enter crowded video game platforms. Additionally, the finding aligns with Boudreau *et al.* (2011) who find that the effect of adding competitors in the context of innovation contest platforms is contingent on the uncertainty and nature of the challenge. In a split-sample analysis comparing innovative with less novel games, I found that the negative effect of competitive crowding is stronger for innovative games.

The importance of complements on platforms' popularity has been emphasized in extant conceptual and empirical work on two-sided markets (Schilling 1998; 1999; 2002; Stremersch *et al.*, 2007; Wareham *et al.*, 2014). Moreover, the added impact of superstar complements on platform adoption is proven to be non-negligible (Binken & Stremersch, 2009; Lee, 2013). Nevertheless, the study of platform complements is still in its early stages and much work remains to be done. Analyzing competitive outcomes between complements in two-sided markets, I found that adoption rates are affected by demand heterogeneities in the form of end-users entering the platform at different points in time. The approach taken here is anchored in, and is supportive of, the emerging body of studies on platforms that shifts focus away from a predominantly price-centered approach typically found in economics studies (Gawer & Cusumano, 2014). Rather than static entities, I approached platforms as dynamic, or as “evolving meta-organizations” (Gawer, 2014). The type of dynamism that was investigated adds to our growing understanding of how competition between the providers of complementary goods on a platform unfolds.

The paper has additional implications for demand-side perspectives in management studies. Demand-based perspectives offer a complementary view to the strategy literature that has been criticized for having a “supply-side bias” (Adner, 2002). Customer heterogeneity can help explain competitive outcomes at the product level (Adner & Levinthal, 2001; Adner & Zemsky, 2006; DeSarbo, Jedidi & Sinha, 2001). Studying products has value for scholars of the resource based view of the firm as it is at the product level where customers assess the value of individual resources and bundles of resources (Lippman & Rumelt, 2003; Sirmon, Gove & Hitt 2008; Wernerfelt, 1984; 2011). After all, consumers are the final arbiters of value (Bowman & Ambrosini, 2000; Priem, 2007). I found that consumers' valuations change as a platform

matures. Late adopters of a technology adopt fewer complementary goods. Furthermore, they let earlier adopters' consumption behavior inform their adoption decisions. These demand-side shifts moderate the impact of indirect network effects and affect competitive outcomes for complements. Besides palpable implications for platform scholars, this finding has implications for firms' resource deployment and resource bundling strategies, adding further validity to the value of demand-based perspectives in strategy and technology innovation studies.

The study's findings further contribute to research on entertainment goods. The theories of mass consumer behavior and the diffusion of innovations have been used before to analyze sales of entertainment goods (Elberse & Oberholzer-Gee, 2008; Elberse, 2013). Competition in these markets is characterized by oversupply, skewed rent distributions, and uncertain product-market outcomes (Caves, 2000; Hirsch, 1972; 2000; Kretschmer, Klimis & Choi, 1999). Trying to resolve uncertainty on the demand-side, consumers typically turn to external selection systems such as expert critics, award bodies, or other consumers for valuation guidance (Priem, 2007; Wijnberg & Gemser, 2000; Wijnberg, 1995; 2004). I found that the joint effect of expert and consumer reviews on game sales is stronger for novel games than for less novel games. This suggests that the impact of selection systems is contingent on the perceived uncertainty of the good, and aligns with previous studies on the differential impact of expert reviews on motion picture performance (Basuroy, Chatterjee & Ravid, 2003; Gemser & Van Oostrum, 2007; Reinstein & Snyder, 2005). Additionally, I found that the skewness between superstar goods and less popular goods increases as technology platforms mature. This finding may inform research on sales distributions and superstar goods on online platforms, including e-books (Fleder & Hosanagar, 2009), online video (Elberse, 2008), and digital film (Weeds, 2012).

Finally, the study has important managerial implications as illustrated by the example of *Watch Dogs*. In May 2014, Ubisoft released its highly anticipated action adventure video game *Watch Dogs* on four platforms spanning two generations of consoles. The innovative game faced an addressable audience of over 160 million ‘current gen’ adopters (PlayStation 3 and Xbox 360) and just shy of 13 million ‘next gen’ platform adopters (PlayStation 4 and Xbox One). Despite this gap in installed bases, over two thirds of the game’s eight million units sold occurred on next generation platforms.²⁷ Notwithstanding some of the paper’s limitations that include issues of causality and a lack of separating demand heterogeneity from social learning effects, the study’s results help explain *Watch Dogs*’ surprising performance and simultaneously hold managerial implications. First, contrary to commonly held managerial perceptions, results show that launching complements early in a platform’s lifecycle when the installed base has not yet reached its full potential may not necessarily be bad for performance. Secondly, complementors should carefully balance their exploration and exploitation efforts contingent on a platform’s maturity. Results indicate that innovation on the complements side yields higher market performance at lower values of platform maturity. Thirdly, the results hold implications for complementors’ portfolio management. Since the adoption disparity between popular and less popular complements increases as platforms mature, complementors are advised to allocate greater resources towards fewer market launches to increase chances for greater market performance.

²⁷ Ubisoft Q1 Sales Conference Call (July 10, 2014). https://www.ubisoftgroup.com/en-us/investor_center/index.aspx - last accessed August 2014

3.7. Conclusion

This paper sought to answer the following research question: *How does platform maturity affect the adoption of complements?* Taking a demand-side perspective, I argued that the shifting composition of end-users on the platform moderates the extent to which complements enjoy indirect network effects. The benefit of a growing installed base is juxtaposed by late adopters' adoption pattern of complements. In my study of sixth generation console video games in the United Kingdom, I found that platform maturity has a concave curvilinear effect on complements' adoption rates. Additionally, platform maturity did not affect all *types* of complements equally. I found that innovative complements enjoy increasingly lower adoption rates than do non-novel complements. Furthermore, the skewness between popular and less-popular complements also widened over the platform lifecycle. End-users with qualitative differences in traits and behaviors enter the platform at different points in time and alter competitive outcomes for the providers of complementary goods.

3.8. Tables & Figures

Table 3.1
Sixth Generation Video Game Consoles (2000-2007)

Video Game Console	Platform Owner	UK Introduction	Platform Lifecycle	UK Launch Price (GBP)	UK Installed Base (1000)	Game Introductions	Next Gen. Introduced (UK)
PlayStation 2	Sony	November 2000	84 months	£ 299.99	9,083	1,775	March 2007
Xbox	Microsoft	March 2002	57 months	£ 299.99	3,110	738	November 2005
GameCube	Nintendo	May 2002	48 months	£ 129.99	1,050	408	December 2006

Table 3.2
Variables and Measures

Variable	Measure	Unit of Analysis
Y_1 <i>Game unit sales</i>	Log-transformation of cumulative unit sales.	Game-platform
Z_1 <i>Platform maturity</i>	Measure of a platform's current installed base at t_j divided by the platform's cumulative installed base at the end of the platform lifecycle. ^a	Platform-month
Z_1 <i>Game quality</i>	Indicator variable that takes the value of 1 if the Metacritic reported average combined critic and user review scores are equal to or greater than 75/100.	Game-platform
Z_1 <i>Game selling price</i>	Log-transformed, inflation corrected, average retail selling price.	Game-platform
Z_1 <i>New IP</i>	Indicator variable that takes the value of 1 if focal game is based on a new intellectual property.	Game-platform
Z_1 <i>Platform sales</i>	Log-transformation of the number of video game consoles sold in $t_j - 1$.	Platform-month
Z_1 <i>Next gen. platform</i>	Indicator variable that takes the value of 1 in months t_j where the focal platform owner introduced a next generation console,	Platform-month
Y_2 <i>Games entry</i>	Count of number of video games entering the platform in month $t_j - 1$, focal game excluded.	Platform-month
Z_2 <i>PPI games publishing</i>	US Producer Price Index (PPI) value for video game publishing in $t_j - 13$.	Platform-month

^a t_j : month of release for the focal game at the platform level.

Table 3.3
Descriptive Statistics and Pearson Correlation Coefficients

Variable	VIF	Mean	s.d.	Min	Max	1	2	3	4	5	6	7	8
1. Game unit sales	-	49503.76	108855	3	2352406								
2. Platform maturity	5.02	0.63	0.28	0.02	1	-0.03							
3. Platform sales	2.02	71723.99	74064.98	1300	770820	0.12	-0.23						
4. New IP	1.09	0.29	0.45	0	1	-0.13	-0.10	0.08					
5. Game quality	1.18	0.31	0.46	0	1	0.18	-0.08	-0.02	-0.06				
6. Game selling price	1.40	21.09	8.33	4.78	119.28	0.27	-0.27	-0.04	-0.19	0.38			
7. Next gen. platform	1.25	0.09	0.28	0	1	-0.04	0.39	-0.22	-0.08	-0.07	-0.10		
8. Games entry	1.66	19.17	11.87	0	59	0.18	0.13	0.48	0.00	-0.06	-0.15	-0.11	
9. PPI games publishing	4.22	98.00	1.49	93.60	101	-0.03	0.87	-0.27	-0.08	-0.12	-0.28	0.52	0.12

Note: Absolute correlations greater than or equal to 0.05 are significant at $p < 0.01$.

Table 3.4

Platform Maturity Effects on Game Unit Sales

Variable	1 (OLS)	2 (OLS)	3 (OLS)	4 (OLS)	5 (OLS)	6 (OLS)	7(2SLS)
Game quality		0.38 (0.06)**	0.38 (0.06)**	0.37 (0.06)**	0.37 (0.06)**	0.36 (0.06)**	0.34 (0.06)**
Game selling price		1.26 (0.10)**	1.27 (0.10)**	1.29 (0.10)**	1.29 (0.10)**	1.33 (0.10)**	1.31 (0.10)**
New IP		-0.30 (0.05)**	-0.32 (0.05)**	-0.31 (0.05)**	-0.31 (0.05)**	-0.30 (0.05)**	-0.30 (0.06)**
Next gen. platform		-0.95 (0.11)**	-0.62 (0.12)**	-0.58 (0.12)**	-0.58 (0.12)**	-0.53 (0.12)**	-0.98 (0.25)**
Platform sales			0.30 (0.04)**	0.29 (0.04)**	0.30 (0.05)**	0.24 (0.05)**	0.46 (0.12)**
Games entry				0.01 (0.00)**	0.01 (0.00)*	0.01 (0.00) +	-0.09 (0.04)*
Platform maturity					0.04 (0.12)	1.16 (0.42)**	3.88 (1.27)**
Platform maturity ²						-1.06 (0.39)**	-2.52 (0.76)**
Constant	9.43 (0.24)**	6.00 (0.37)**	2.16 (0.34)**	2.03 (0.67)**	1.91 (0.77)*	2.45 (0.80)**	1.16 (1.09)
Platform fixed effects	YES	YES	YES	YES	YES	YES	YES
Calendar month fixed effects	YES	YES	YES	YES	YES	YES	YES
Genre fixed effects	YES	YES	YES	YES	YES	YES	YES
Publisher fixed effects	YES	YES	YES	YES	YES	YES	YES
Observations	2855	2855	2855	2855	2855	2855	2855
R ²	0.46	0.55	0.56	0.56	0.56	0.56	-

Heteroskedasticity robust standard errors reported in parentheses.

Games entry is instrumented in model 7.

The first-stage coefficient for instrumental variable *PPI games publishing* is -0.16 (0.04) $p < 0.01$.

** $p < .01$, * $p < .05$, + $p < .10$

Table 3.5
Platform Maturity Effects on Novel and Non-Novel Games

Variable	Novel (OLS)	Non-novel (OLS)	Novel (2SLS)	Non-novel (2SLS)
Game quality	0.65 (0.11)**	0.31 (0.07)**	0.56 (0.14)**	0.31 (0.07)**
Game selling price	0.84 (0.17)**	1.50 (0.12)**	0.78 (0.19)**	1.49 (0.12)**
Next gen. platform	-1.39 (0.35)**	-0.37 (0.13)**	-2.22 (0.54)**	-0.61 (0.28)*
Platform sales	0.11 (0.10)**	0.30 (0.06)**	0.71 (0.34)*	0.41 (0.12)**
Games entry	0.00 (0.00)	0.01 (0.00) +	-0.22 (0.10)*	-0.04 (0.05)
Platform maturity	0.95 (0.75)	1.51 (0.53)**	7.29 (3.02)*	2.81 (1.52)*
Platform maturity ²	-1.44 (0.75)*	-1.13 (0.48)*	-4.98 (1.86)**	-1.80 (0.80)*
Constant	4.84 (1.35)**	1.47 (0.97)	2.37 (2.71)	0.74 (1.22)
Platform fixed effects	YES	YES	YES	YES
Calendar month fixed effects	YES	YES	YES	YES
Genre fixed effects	YES	YES	YES	YES
Publisher fixed effects	YES	YES	YES	YES
Observations	826	2029	826	2029
R ²	0.66	0.54	-	-

Heteroskedasticity robust reported standard errors in parentheses.

Games entry is instrumented in the 2SLS models. The first-stage coefficient for *PPI games publishing* is -0.17 (0.07) $p < 0.05$ for novel games and -0.16 (0.05) $p < 0.01$ for non-novel games.

Wald-tests show that there is a difference between the effect of *platform maturity* ($\chi^2 = 3.75$; $p < 0.10$) and *platform maturity*² ($\chi^2 = 4.98$; $p < 0.05$) on games unit sales between both subsamples.

** $p < .01$, * $p < .05$, + $p < .10$

Table 3.6
Platform Maturity Effects on Popular & Less Popular Games

Variable	Q25 (SQR)	Q50 (SQR)	Q75 (SQR)	Q25 (CFQR)	Q50 (CFQR)	Q75 (CFQR)
Game quality	0.50 (0.08)**	0.48 (0.07)**	0.44 (0.07)**	0.51 (0.08)**	0.48 (0.09)**	0.43 (0.07)**
Game selling price	1.61 (0.12)**	1.70 (0.10)**	1.71 (0.09)**	1.61 (0.13)**	1.71 (0.12)**	1.73 (0.09)**
New IP	-0.48 (0.09)**	-0.47 (0.07)**	-0.41 (0.07)**	-0.48 (0.09)**	-0.46 (0.07)**	-0.42 (0.08)**
Next gen. platform	-0.64 (0.17)**	-0.23 (0.18)	-0.26 (0.15)+	-0.55 (0.21)**	-0.74 (0.31)*	-1.15 (0.58)*
Platform sales	0.27 (0.08)**	0.38 (0.08)**	0.24 (0.07)**	0.23 (0.10)*	0.44 (0.09)**	0.55 (0.19)**
Games entry	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)*	-0.02 (0.03)	-0.08 (0.04)+	-0.15 (0.09)+
Platform maturity	2.30 (0.61)**	1.81 (0.56)**	1.59 (0.63)*	1.92 (1.02)+	4.57 (1.52)**	5.02 (1.79)*
Platform maturity ²	-2.07 (0.58)**	-1.41 (0.53)**	-1.16 (0.58)*	-1.89 (0.71)**	-3.00 (0.97)**	-2.60 (0.78)**
Constant	0.57 (1.180)	0.01 (1.24)	2.33 (1.05)+	0.98 (1.25)	0.81 (1.03)	2.75 (1.13)*
Platform fixed effects	YES	YES	YES	YES	YES	YES
Calendar month fixed effects	YES	YES	YES	YES	YES	YES
Genre fixed effects	YES	YES	YES	YES	YES	YES
Publisher portfolio fixed effects	YES	YES	YES	YES	YES	YES
Observations	2855	2855	2855	2855	2855	2855
Pseudo R ²	0.21	0.23	0.25	-	-	-

SQR: Simultaneous Quantile Regression. CFQR: Control Function Quantile Regression.

All models estimated via weighted least absolute deviations with standard errors obtained via bootstrapping using 100 draws.

Games entry instrumented by Ma & Koenker's (2006) Control Function Quantile Regression. The first-stage coefficient for *PPI games publishing* in medium least absolute deviation (Q50) estimation is -0.22 (0.04) $p < 0.01$.

** $p < .01$, * $p < .05$, + $p < .10$

Table 3.7
Within Game Effects of Platform Maturity on Sales

Variable	Multi-home (2SLS)
Game quality	0.10 (0.09)
Game selling price	-0.61 (0.19)**
Next gen. platform	-0.82 (0.13)**
Platform sales	0.69 (0.08)**
Games entry	-0.07 (0.02)**
Platform maturity	1.67 (0.67)*
Platform maturity ²	-2.80 (0.76)**
Constant	4.95 (1.81)**
Platform fixed effects	YES
Calendar month fixed effects	YES
Genre fixed effects	YES
Publisher fixed effects	YES
Game fixed effects	YES
Observations	1492

Heteroskedasticity robust reported standard errors in parentheses.

Games entry is instrumented with *PPI games publishing*: 5.34 (0.92) $p < 0.01$.

** $p < .01$, * $p < .05$

Table 3.8

Propensity-score Matching Effects of New IP on Games Unit Sales

Platform Maturity	Average Treatment Effect
New IP (all observations)	-0.55 (0.08)**
<i>New IP splined by Platform Maturity:</i>	
0-10% (127 obs.)	0.16 (0.23)
10-20% (153 obs.)	-0.15 (0.27)
20-30% (220 obs.)	-0.39 (0.21)+
30-40% (140 obs.)	-0.46 (0.19)*
40-50% (325 obs.)	-0.15 (0.17)
50-60% (202 obs.)	-0.40 (0.22)+
60-70% (313 obs.)	-0.53 (0.19)**
70-80% (285 obs.)	-0.52 (0.18)**
80-90% (440 obs.)	-0.67 (0.24)**
90-100% (650 obs.)	-1.00 (0.24)**
Observations	2855

Heteroskedasticity robust standard errors reported in parentheses.

Propensity-scores based on nearest neighbor matching.

Logit coefficients for matching covariates: *Platform maturity* (-1.03; $p < 0.01$); *game quality* (0.19; $p < 0.10$); *game selling price*; (-1.42; $p < 0.01$); *platform sales* (0.15; $p < 0.10$); *Games entry* (-0.01; $p < 0.01$); and, *next gen. platform* (-0.46; $p < 0.05$).

** $p < .01$, * $p < .05$, + $p < .10$

Figure 3.1

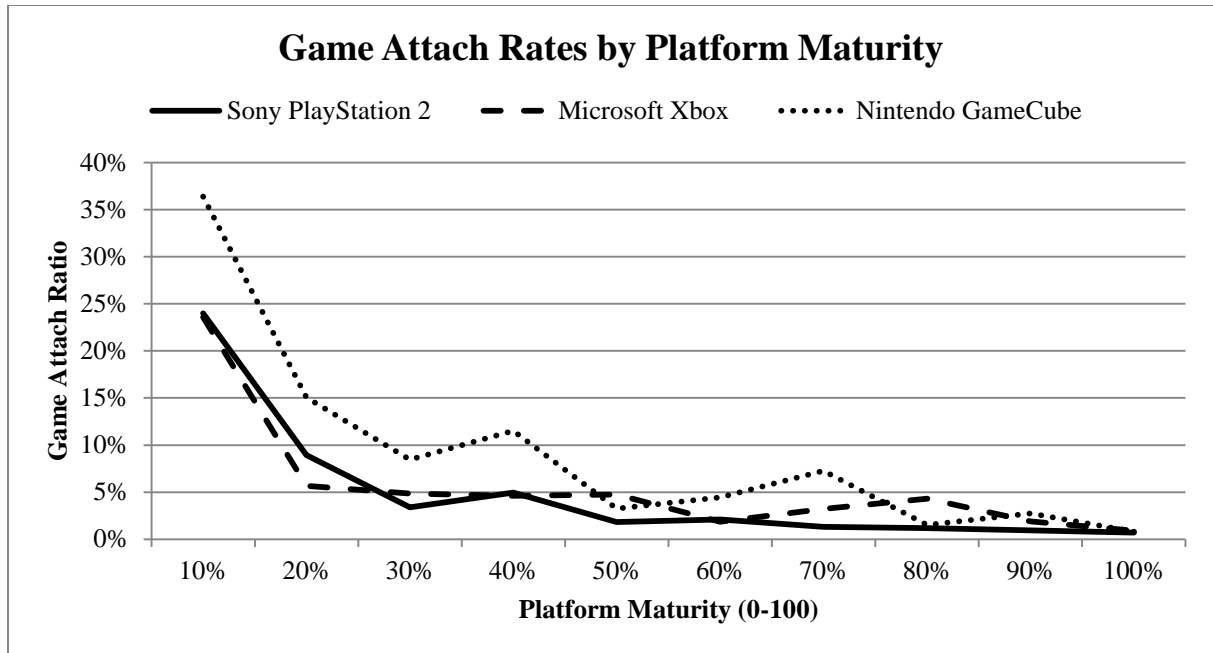


Figure 3.2

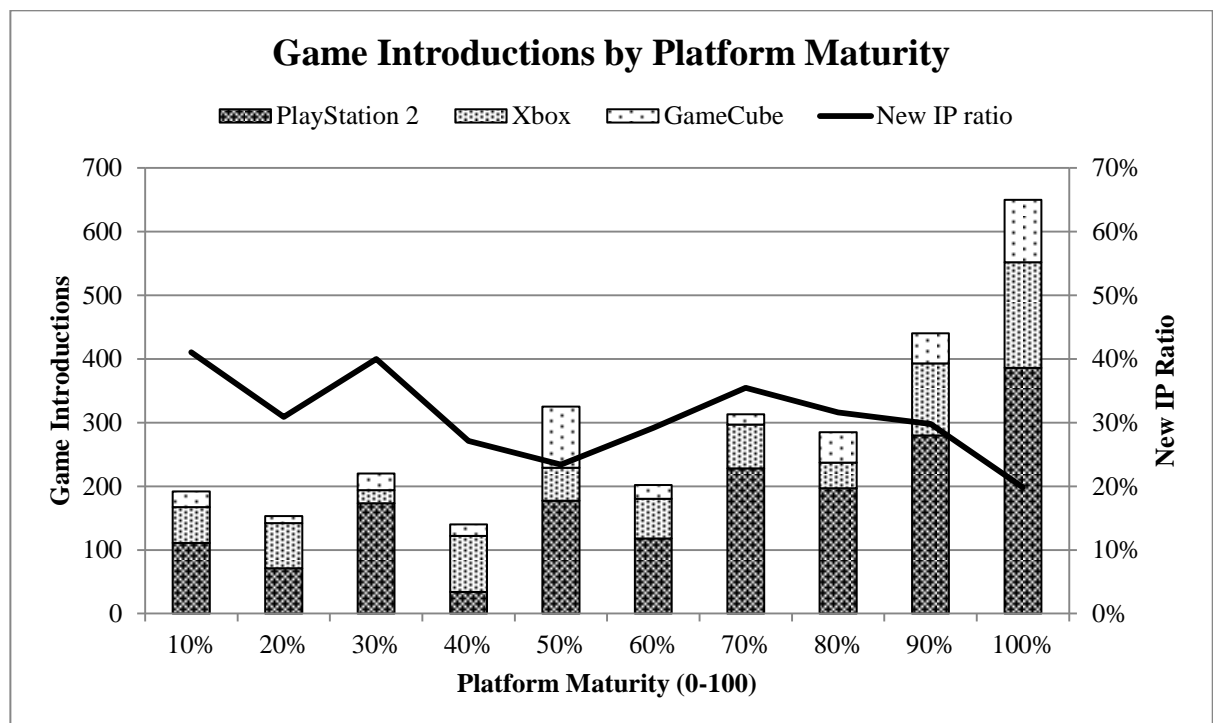


Figure 3.3

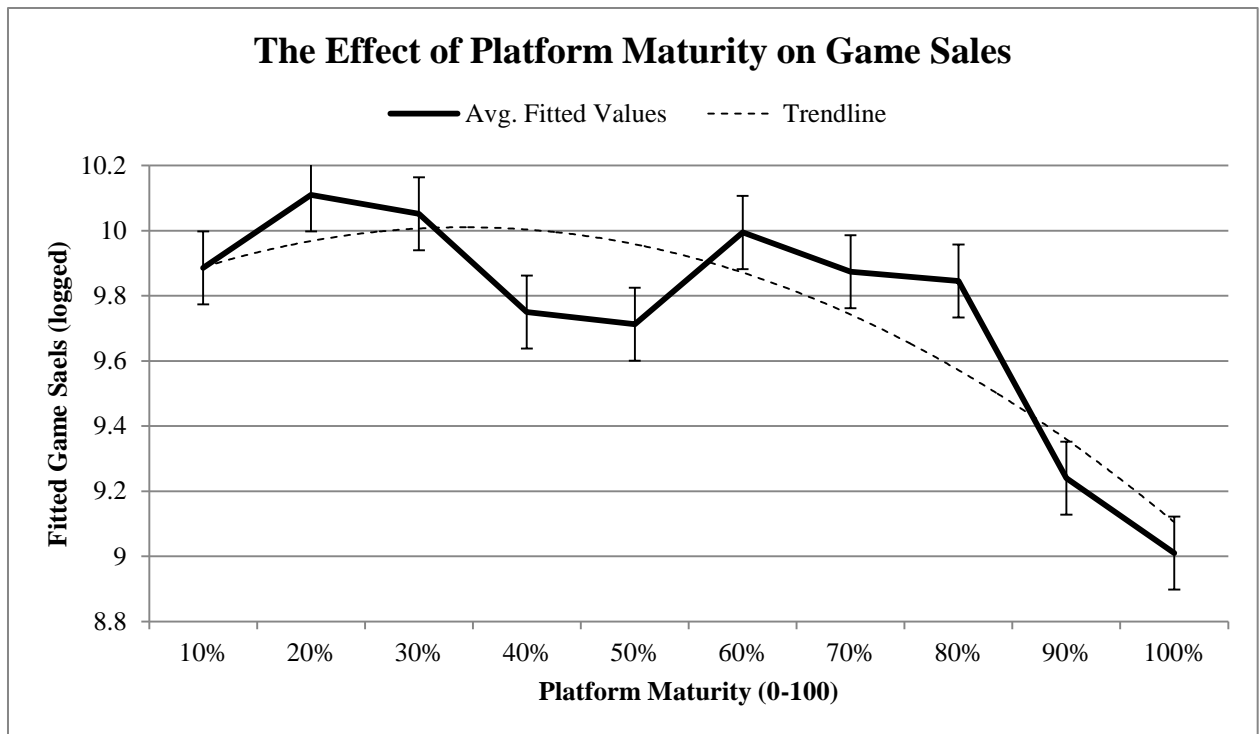


Figure 3.4

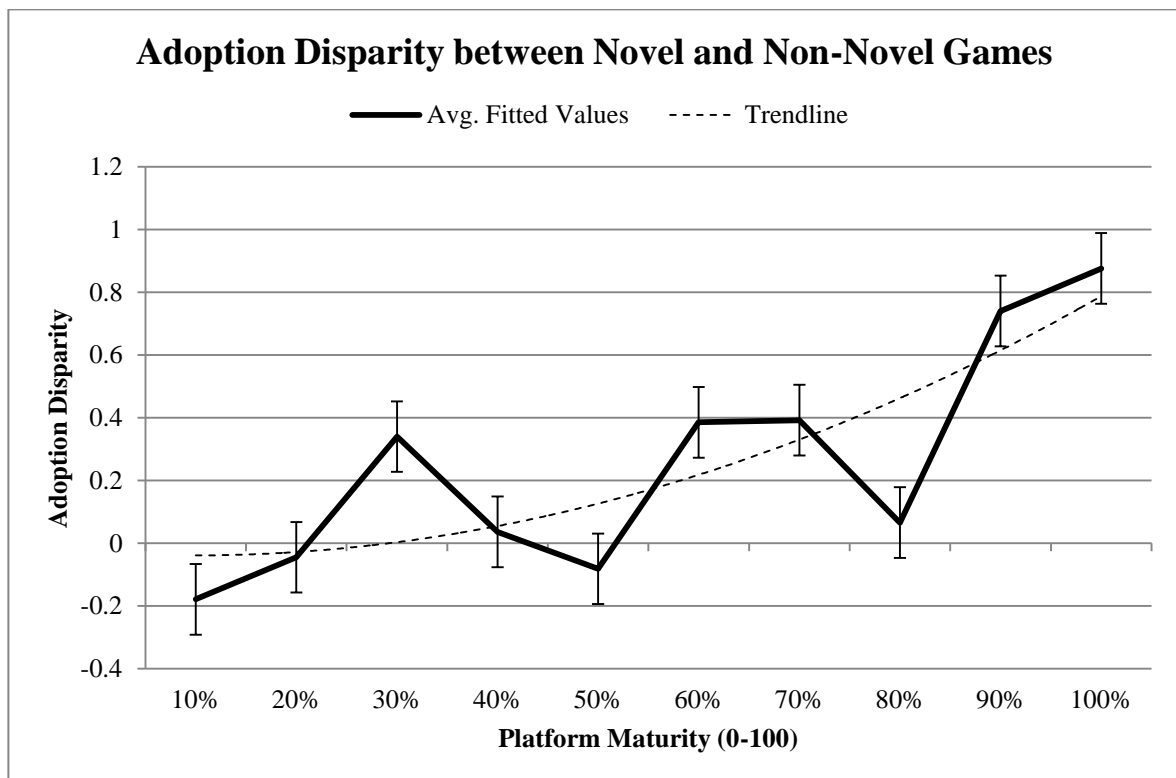


Figure 3.5

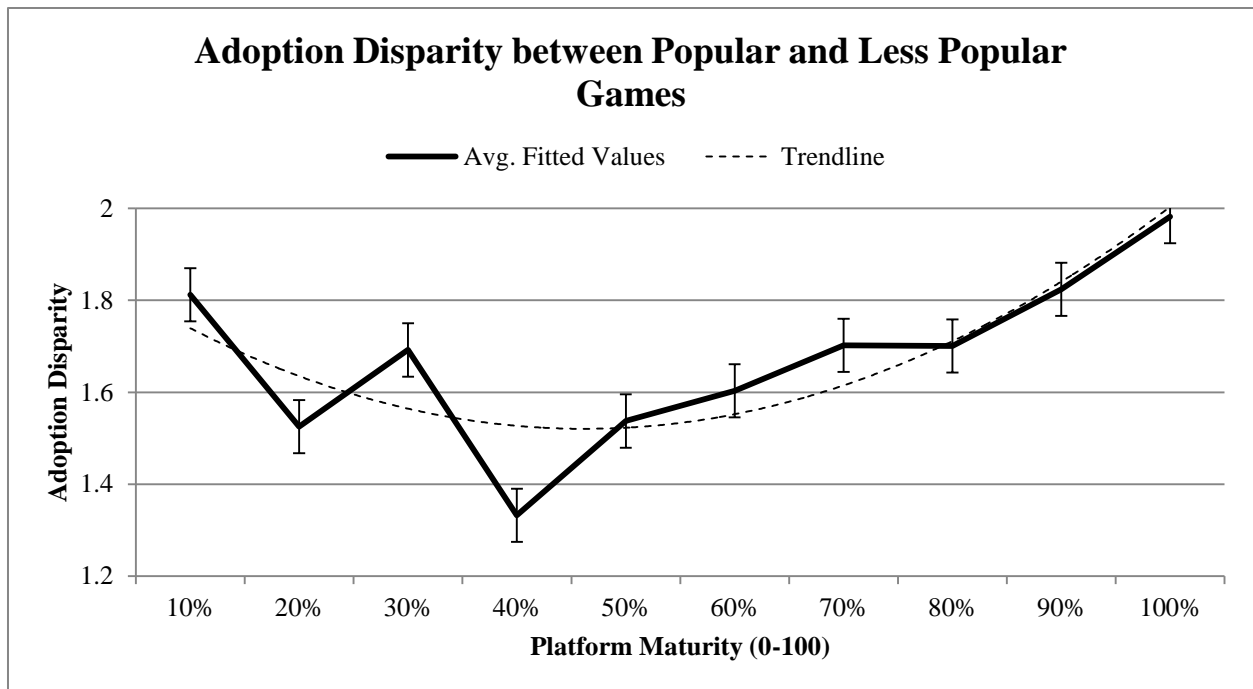
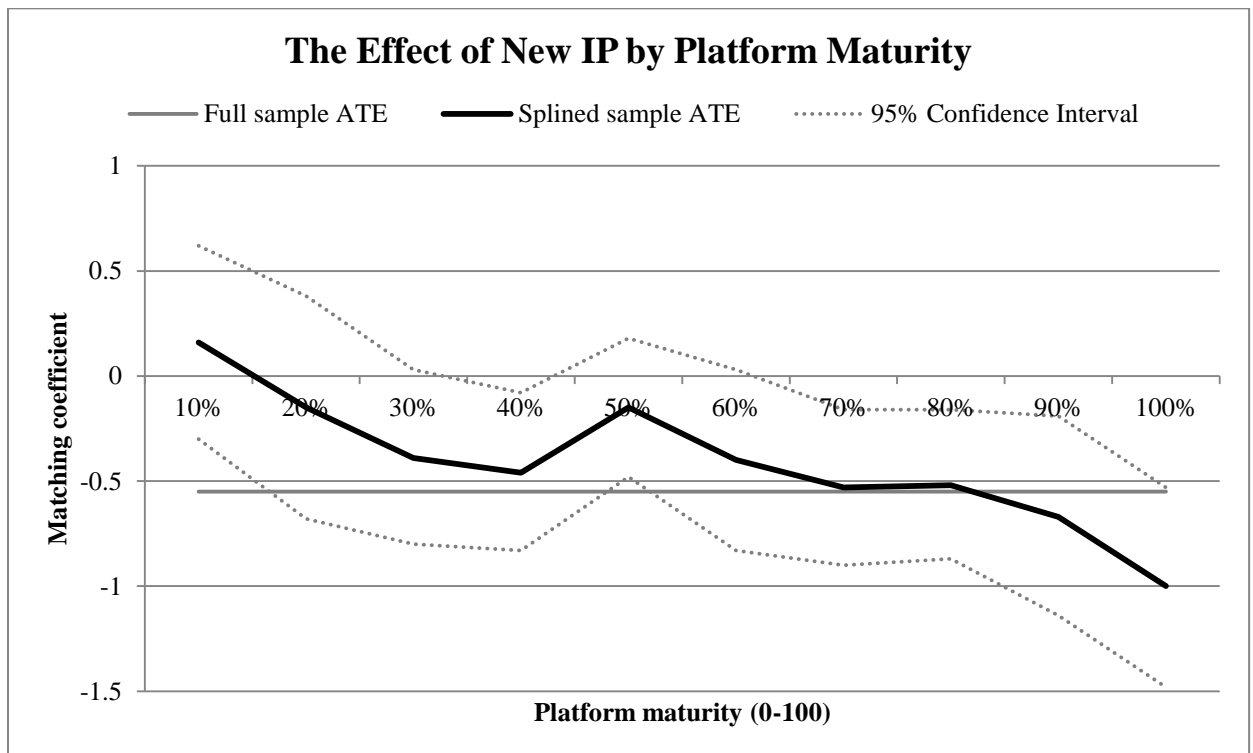


Figure 3.6



4. NEW HORIZONS OR A STRATEGIC MIRAGE? ARTIST-LED-DISTRIBUTION VERSUS ALLIANCE STRATEGY IN THE VIDEO GAME INDUSTRY²⁸

4.1. Introduction

Technological advancements have dramatically increased the ability of content producing entrepreneurs in the creative industries to commercialize their output directly to consumers without having to rely on powerful publishers and distributors as intermediaries. This change has meant that content-producing entrepreneurs can now singlehandedly publish their content onto online stores such as Apple's iTunes, Amazon's Kindle store, or Nintendo's WiiWare. The shift to what has been referred to as 'artist-led-distribution' (Clemons & Lang, 2003) has set off a debate on whether this tilts the fundamental power balance within creative industries in favor of content producers, or it represents an additional means of distribution with limited strategic potential (Bockstedt *et al.*, 2006).

On the one hand, we have researchers that argue that such artist-led-distribution will revolutionize the creative industries, allowing content-producing entrepreneurs to bypass the traditional reliance on publishers, and appropriate the full value of their creativity (Bockstedt *et al.*, 2006; Clemons *et al.*, 2003; Clemons & Lang, 2003). At the same time, other researchers have been more critical, arguing that notwithstanding the opportunities offered by

²⁸ This paper is co-authored with Professor Joseph Lampel at Cass Business School and Professor Thijs L.J. Broekhuizen at the University of Groningen. The paper was submitted for publication consideration with Research Policy in June 2011 and was accepted for publication in December 2012. The authors acknowledge the valuable input of Wilfred Dolfsma who provided guidance on an early version of the manuscript. We would also like to thank participants at the March 14 2012 research seminar at Nottingham University Ningbo, China, as well as the participants at the 2nd Tilburg Conference on Innovation, held at Oisterwijk, the Netherlands, on June 16 2012 for useful input. We kindly thank two anonymous reviewers for their comments on the manuscript. The preferred reference for this paper is:

Broekhuizen, T.L.J., Lampel, J. and Rietveld, J. 2013. New Horizons or a Strategic Mirage? Artist-led-distribution Versus Alliance Strategy in the Video Game Industry. *Research Policy*, 42 (4), 954-964.

Authors are listed in alphabetical order, and all authors contributed equally.

5. GAME CHANGERS: BUSINESS MODEL INNOVATION IN THE UK MARKET FOR DIGITAL VIDEO GAMES³⁵

5.1. Introduction

A central theme in the literature on business models is the concept of business model innovation and the facilitating role of technological change herein (Amit & Zott, 2001; Baden-Fuller & Haefliger, 2013; Teece, 2010). Technological disruptions such as mass production in the early twentieth century, and more recently the advent of digital distribution in the creative industries, allow for novel pathways of doing business.³⁶ Take for example the case of R&B singer Beyoncé. In 2013, Beyoncé released her self-titled studio album directly and exclusively on digital distribution platform iTunes, bypassing powerful distributors and retailers. Claiming “that releasing albums the old fashioned way is boring,” the artist included a music video for every song on the album as a promotional strategy.³⁷ Similarly, video game developer Mojang allowed fans to download an early prototype of its video game *Minecraft* at a discounted rate. Using feedback from early users helped improve the game before its commercial launch and, perhaps more importantly, the income generated from nearly four million paying ‘testers’ allowed Mojang to complete and commercialize its hit title without the help of an established publisher.

³⁵ This paper is co-authored with Joost van Dreunen Adjunct Faculty at New York University and Professor Charles Baden-Fuller at Cass Business School. We kindly thank the following people for providing useful feedback on our research design and earlier versions of the manuscript: Stefan Haefliger, Gino Cattani, Thijs Broekhuizen and, Daniel Wood (Ukie). We received actionable feedback from participants during two seminar presentations at Stern School of Business and the business models subtheme at the 30th EGOS Colloquium in Rotterdam (Netherlands). We thank Maarten de Jong for research assistance. We thank five industry experts for providing invaluable feedback on our survey design, the respondents to our survey, and our case study informants. All mistakes are our own.

³⁶ The term pathway is used throughout this paper as a term indicating how firms go about creating products (e.g. partnerships with external actors) as well as how firms go about entering marketplaces, or platforms in the context of digitally distributed platforms. The term pathway was used in prior work on business models by Chesbrough (2007; 2012; 2013), and the multitude of the term in this paper links to the two dimensions for business model innovation (*external actor dependencies* and *end-user engagement*).

³⁷ Liz Smith, “Musically ‘Bored’ Beyonce Does it Her Way, Now”, *The Huffington Post*, December 16, 2013, http://www.huffingtonpost.com/liz-smith/musically-bored-beyonce-d_b_4453104.html, accessed August 2014.

6. CONCLUSION

How does platform-level variation affect value creation strategies and market performance for complementors in platform-based markets? Supported by recent calls for future research taking a management perspective on platform studies (Gawer, 2014; Jacobides *et al.*, 2015; Wareham *et al.*, 2014), this dissertation set out to provide an exploratory account of how platform-level variation affects competitive dynamics for firms operating at the periphery of platform ecosystems rather than at the core. Through empirical enquiry in the video game industry using both quantitative and qualitative analysis, I and my co-authors arrive at several findings. These findings are summarized in table 6.1, whilst further elaborated on below.

--- INSERT TABLE 6.1 HERE ---

In the first study (Chapter 3), I relax the assumption that platforms are static entities to study the effect of platform maturity on cumulative unit sales of 2,855 sixth generation console video games in the U.K. (2000–2007). As platforms mature, the composition of end-users evolves to include an increasing number of late adopters who display different traits and behavioral attributes from early adopters (Von Hippel, 1986; Juul, 2010). Studying this end-user demand heterogeneity by drawing on the diffusion of innovations literatures (Banerjee, 1992; McPhee, 1963; Rogers, 2003, Young, 2009), I postulate and find support for a curvilinear effect of platform maturity on video games’ cumulative unit sales at the game-platform level. Controlling for endogenous market entry by video game producers and supply-side heterogeneity, I further find that when platforms mature, the adoption disparity between novel and non-novel and between superstar and less-popular video games increases at the benefit of non-novel and superstar games. Additional findings include a 8.60% drop in games’ average cumulative unit sales following entry of one additional game onto the platform, lending

empirical support to the “competitive crowding” hypothesis (Boudreau, 2012; Boudreau & Jeppesen, 2014). And, a 4.58% increase in games’ average cumulative unit sales following a 10% increase in platform sales lending empirical support for cross-platform network effects (Clements & Ohashi, 2005; Parker & Van Alstyne, 2005; Stremersch *et al.*, 2007).

The second study (Chapter 4) takes advantage of a naturally occurring quasi-experiment of a Dutch Video Game Developer (DVGD) bringing to market identical content using two distinct market entry strategies: (1) independently, bypassing owners of specialized complementary assets (Teece, 1986; 2006), and (2) through forging an alliance with a specialized complementary asset owner (a reputable publisher of digital video games). I and my co-authors, Thijs Broekhuizen and Joseph Lampel, find that the benefits of forging an alliance outweigh its costs. DVGD’s content enjoyed higher absolute and relative market performance under the alliance strategy. And, while the publisher negotiated a royalty fee of 10-15% for its services, net revenues under the alliance strategy surpassed those of the independent commercialization strategy by €7,169, or 8.11%. A significant increase in sales occurred when the platform owner prominently featured DVGD’s game onto the platform’s storefront boosting sales by nearly 1,000 units per day, or 355%. We attribute this spike in sales to the publisher’s relationship with the platform owner. The study contributes to an ongoing debate about whether specialized complementary asset owners add value through their market access granting privileges (Bockstedt *et al.*, 2006; Clemons *et al.*, 2003; Clemons & Lang, 2003), or by virtue of their complementary asset portfolios (Colombo *et al.*, 2006; Gans & Stern, 2003; Mol *et al.*, 2005; Rothaermel, 2001).

The third study (Chapter 5) builds on the findings outlined above by exploring how managers in the U.K. market for video game production have changed their firms’ business

models after the advent of digital distribution platforms. Using a mixed methods inquiry of 41 survey responses and four case study firms, I and my co-authors Joost van Dreunen and Charles Baden-Fuller find that the motivation for managers who have recently changed (34%) or intent to change (24%) their business models, is not exclusively linked to increased market performance. Virtually eroded barriers to market entry and fragmentation of content bundles in digital distribution platforms have, in fact, dramatically intensified competition and further skewed market performance outcomes in such markets (e.g. Elberse & Oberholzer-Gee, 2008; Fleder & Hosanagar, 2009). Instead, our qualitative findings lead us to conclude that managers' motivation for implementing novel business models can be traced back to a cognitive tension between creativity and rationalization prevalent in the creative industries (Lampel *et al.*, 2000; Tschang, 2007). Reducing external actor dependencies, or increasing end-user engagement (or a combination thereof) allows firms to exercise greater degrees of creative freedom vis-à-vis the *de facto* work-for-hire business model.

The dissertation's main contribution is to the literatures on multisided platforms and ecosystems. The dissertation aimed to provide an empirical testimony to the value of research on multisided platforms from a management perspective (Gawer, 2014; Jacobides *et al.*, 2015). The three empirical studies show that such a perspective is useful, relevant and arguably generates interesting insights for a cross-disciplinary community of scholars interested in platform markets. Within this perspective, the dissertation aspired to make specific contributions to the nascent, yet growing body of research on complementors and platform complements (Boudreau, 2012; Boudreau & Jeppesen, 2014; Venkatraman & Lee, 2004). The dissertation offered additional implications for management research taking a demand-perspective on technological innovations (Adner & Levinthal, 2001). Drawing insights from marketing, strategy scholars increasingly

realize the importance of demand-environments on firms' value creation and value capturing strategies (Adner, 2002; Adner & Zemsky, 2006; Priem, 2007). In this light, I have shown that changes on the demand-side affect competitive outcomes for firms operating at the periphery of platform ecosystems, and that these changes moderate the extent to which certain value creation strategies (novel vs. non-novel complements) are more or less effective. Further contributions were made to the literatures on complementary assets (Teece, 1986; 2006), business models (Amit & Zott, 2001; Baden-Fuller & Morgan, 2010), and scholarly work on the creative industries (Caves, 2000; Hirsch, 1972; Lampel *et al.*, 2000). Appendix C provides an overview of the dissertation's overall academic and practical impact.

The dissertation has certain shortcomings and limitations. Most noticeably, the dissertation suffers from some ex-post rationalization. When my doctoral program started in October 2010, there was no such thing as a 'management perspective on multisided platforms'. Gawer's (2009) edited volume on platforms had just been published, and I was inspired by the economics literature on two-sided markets (e.g. Binken & Stremersch, 2009; Clements & Ohashi, 2005; Rochet & Tirole, 2003; 2006). In absence of a platform specific framework, the studies presented in chapters four and five were conducted and written up using more traditional conceptual lenses. A second limitation that follows the dissertation's exploratory nature is an overall lack of large-sample empirical testing. With the exception of the study presented in Chapter 3, the empirical studies largely draw on qualitative estimation techniques, making generalization of the findings problematic. The use of a single industry setting further complicates generalizability. A third limitation is that the actions by platform owners were treated as exogenous when they often are, in fact, endogenous. When app developer Aurora Feint launched its social discovery platform *OpenFeint* on Apple's App Store, developers of 900 apps

decided to bypass Apple's internal discovery tools. A year later, Apple responded to this form of platform envelopment (Eisenmann, Parker & Van Alstyne, 2011) by making its own discovery platform, *Game Center*, an integral part of the iOS operating system rendering *OpenFeint* obsolete. Future research may address how platforms change their regulation policies and levels of openness following the strategic actions by complementors (Boudreau, 2010; Boudreau & Hagi, 2009).

Firms operating at the periphery of multisided platforms, such as the producers of video games and mobile app developers, are affected by variation at the core. From an aggregate perspective, this variation can be endogenous (induced by platform owner governance and regulation) or exogenous (driven by the underlying economics of platforms' *multisided-ness*). Where extant work began to address the effect of these forms of variation on platform competition, this dissertation has taken the reverse perspective. By presenting the findings from three empirical studies in the video game industry, this dissertation provided an exploratory account of how several forms of platform-level variation (e.g. end-user demand heterogeneity, barriers to market entry, platform owner endorsements) affect value creation strategies (e.g. access to complementary assets, business model design) and market performance outcomes for providers of complementary goods. Although some effects were studied through preexisting conceptual lenses in the strategic management literature, others could only be meaningfully analyzed by taking a platform perspective. As such, and while much work on platform dynamics remains to be done, the dissertation favorably attests to the theoretical and practical value of research on platforms (and its constituents) from a management perspective.

6.1. Table

Table 6.1
Dissertation's Main Findings

	CHAPTER 3 - DEMAND HETEROGENEITY	CHAPTER 4 - NEW HORIZONS OR STRATEGIC MIRAGE?	CHAPTER 5 - GAME CHANGERS
Platform-level variation	Intra platform demand heterogeneity	Inter-platform barriers to market entry	Inter-platform barriers to market entry
Value creation strategy	Intensity of market entry (continuous)	Access to complementary assets (binary)	Business model design (bidimensional)
Market performance	Cumulative unit sales (continuous)	Unit sales and revenues (continuous)	-
Unit of analysis	Platform-complement	Platform-complement	Managerial cognition and firm
Empirical context	UK market for console video games (2000-2007)	Dutch digital games developer (2008-2009)	UK market for digitally distributed video games (2012-2013)
Methodology	Quantitative	Qualitative	Mixed
Method(s)	Reduced form regressions (n=2,855)	Naturally occurring quasi-experiment (n=1)	Survey (n=41); case studies (n=4)
Main finding	Demand heterogeneity on the platform end-user side moderates the magnitude of indirect network effects enjoyed by complements. The moderation effect varies for different <i>types</i> of complements.	Access to specialized complementary asset owners may not pose a bottleneck to market entry (anymore), bypassing these actors nevertheless results in sub-optimal market performance.	Business model design acts as a tool for balancing the cognitive tension between creativity and rationalization in the creative industries, as opposed to solely acting as a means for improved competitive outcomes.
Secondary finding	In the market for console video games there exist negative direct network effects as higher levels of market entry lead to lower relative market performance for complements.	Platform owner governance in the form of digital storefront 'features' positively affects market performance for treated complements.	In the market for digitally distributed video games, complementors operate four (novel) business model designs: (1) work-for-hire; (2) artist-led-distribution; (3) freemium; (4) multisided.
Research question: <i>How does platform-level variation affect value creation strategies and market performance for complementors in platform-based markets?</i>			

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APPENDIX A: FIRST STAGE REGRESSION RESULTS (CHAPTER 3)

This section diagnoses the first stage estimations to evaluate the strength and relevance of the instrumental variable. Instrumental variable *PPI games publishing* measures the average change (in percentage points) over time in the selling prices of video games for game publishers in the US. An increase in PPI implies higher production costs for video game producers and imposes greater barriers to market entry. Taking video games' production cycles into account, I lag the variable by one year. I expect increases in *PPI games publishing* in $t_j - 13$ to negatively impact the number of games entering the platform in $t_j - 1$. First stage OLS regression results for the entire sample and split sample estimations are reported in table A-1.

--- INSERT TABLE A-1 HERE ---

In line with the above, I find a negative effect of *PPI games publishing* (-0.16; $p < 0.01$). Increases in the costs of making video games in $t_j - 13$ lead to a decrease in *Games entry* by game producers in $t_j - 1$. This result holds when I split the sample between video games based on *new IP* and those that are not. I utilize the split-sample results to test for monotonicity, the assumption that the instrument treats all affected subjects equally (Angrist, Imbens & Rubin, 1996). A Wald-test comparing the coefficients of the excluded instrument for novel and non-novel complements fails to reject the null hypothesis of monotonicity ($\chi^2 = 0.03$). This result can be interpreted as the instrumental variable affecting games that are based on new IP and those that are not equal. The outcome of an F-test (19.38; $p < 0.01$) shows that the excluded instrument is sufficiently correlated with the endogenous covariate.

--- INSERT TABLE A-2 HERE ---

First stage estimations for the CFQR are reported in table A-2. The results show that the excluded instrument affects the lower quantiles ($\tau = 25$: -0.31; $p < 0.01$) in the distribution of *Games entry* more strongly than it affects the higher quantiles ($\tau = 75$: -0.10; *n.s.*). Increases in the production costs of video games hinder *Games entry* in the bottom quantile whereas increases in production costs do not necessarily hinder *Games entry* in the upper quantile of the distribution. This validating result is graphically depicted in figure A-1 below.

--- INSERT FIGURE A-1 HERE ---

In short, the lagged *PPI Games publishing* covariate is a relevant instrument that sufficiently affects the number of games entering a video game. Across all models, the direction and significance levels of other variables in the models are as expected. Platform level covariates (i.e. *platform sales*, *next gen. platform*, and *platform maturity*) impact *Games entry* as expected whereas game-level covariates (i.e. *game quality*, *game selling price*, and *new IP*) do not. These findings further add to the validity of the first stage estimations.

Table A-1
First Stage Regressions: Games Entry

Variable	Full Sample (OLS)	Novel (OLS)	Non-novel (OLS)
Game quality	-0.11 (0.27)	-0.36 (0.47)	-0.01 (0.32)
Game selling price	-0.14 (0.37)	-0.22 (0.62)	-0.28 (0.49)
Platform sales	1.96 (0.38)**	2.28 (0.78)**	1.91 (0.45)**
Next gen. platform	-5.41 (0.50)**	-4.64 (1.17)**	-5.76 (0.57)**
Platform maturity	19.05 (3.09)**	18.33 (5.20)**	18.59 (3.90)**
Platform maturity ²	-11.03 (2.33)**	-11.05 (3.97)**	-10.15 (2.93)**
New IP	-0.03 (0.24)		
PPI games publishing	-0.16 (0.04)**	-0.17 (0.07)*	-0.16 (0.05)**
Constant	2.77 (6.32)	6.59 (12.49)	0.06 (7.59)
Platform fixed effects	YES	YES	YES
Calendar month fixed effects	YES	YES	YES
Genre fixed effects	YES	YES	YES
Publisher fixed effects	YES	YES	YES
Observations	2855	826	2029
R ²	0.78	0.81	0.78

Heteroskedasticity robust standard errors reported in parentheses.

Excluded instrument: *PPI Games publishing*

** $p < .01$, * $p < .05$

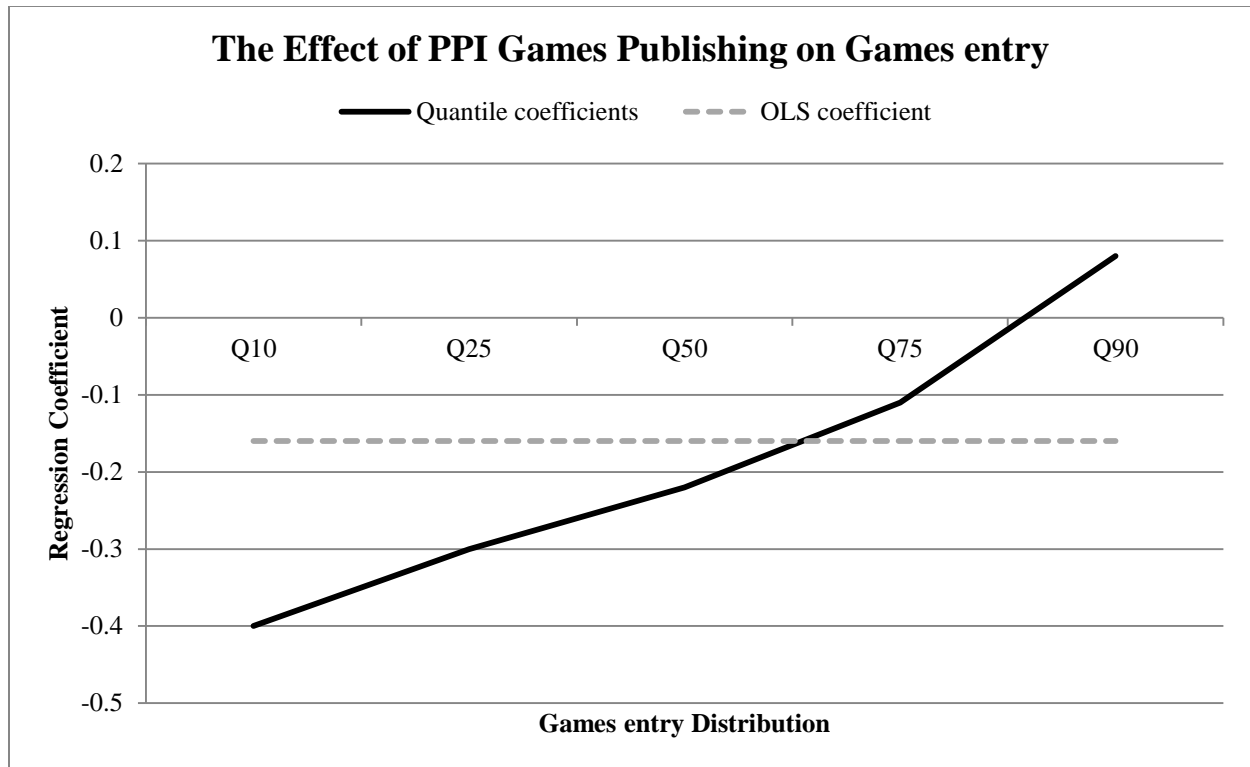
Table A-2
First Stage Quantile Regressions: Games Entry

Variable	Q25 (SQR)	Q50 (SQR)	Q75 (SQR)
Game quality	-0.05 (0.10)	-0.17 (0.14)	0.00 (0.18)
Game selling price	-0.06 (0.13)	-0.17 (0.15)	0.00 (0.24)
New IP	0.06 (0.11)	0.00 (0.13)	0.00 (0.23)
Next gen. platform	-5.31 (0.75)**	-6.43 (0.52)**	-6.26 (1.24)**
Platform sales	1.03 (0.31)**	0.71 (0.38)+	1.88 (0.92)*
Platform maturity	15.74 (3.25)**	19.40 (3.67)**	13.45 (4.63)**
Platform maturity ²	-12.91 (2.50)**	-12.62 (2.74)**	-4.24 (4.16)
PPI games publishing	-0.31 (0.02)**	-0.20 (0.04)**	-0.10 (0.08)
Constant	18.42 (4.83)**	25.58 (7.11)**	11.44 (13.61)
Platform fixed effects	YES	YES	YES
Calendar month fixed effects	YES	YES	YES
Genre fixed effects	YES	YES	YES
Publisher portfolio fixed effects	YES	YES	YES
Observations	2855	2855	2855
Pseudo R ²	0.56	0.59	0.61

Models estimated via weighted least absolute deviations with bootstrapped standard errors from 100 draws. Excluded instrument: *PPI games publishing*.

** $p < .01$, * $p < .05$, + $p < .10$

Figure A-1



APPENDIX B: SURVEY ITEMS (CHAPTER 5)

Table B-1
Survey Items and Operationalization

Item	Type	Notes
1. How important is the choice of business model to your success?	5 point Likert-scale	Not at all important; Very unimportant; Neither important nor unimportant; Very important; Extremely important
2. Did you always operate this business model?	Binary choice	If no: Please, tell us about the previous one (only one) and why you changed:
3. Are you thinking of changing your business model?	Binary choice	If yes: Please tell us why?
4. My company is a Ukie member:	Binary choice	
5. We generate income through the following revenue streams:	Count*	Units sold; Pre-order; A revenue share as part of games bundles; Subscription fees; Pay-per-play; Virtual gambling; Micro transactions; Virtual currencies; Downloadable content/in-app purchases; Pay what you want; User-generated content; Selling game related content (e.g. licensing); Project-based/work-for-hire; Around game advertising (e.g. banners, bumpers); In-game advertising; Selling player details / information; Revenue share / Royalties*
6. In which year was your company founded?	Drop down menu	1960-2012
7. Our main customers are:	Multiple choice	Players; Businesses; Both equally
8. Approximately, XX of our income is generated by post-release revenue streams:	Multiple choice	0-20%; 21-40%; 41-60%; 61-80%; 81-100%
9. Approximately, XX of our budget spent on development activities post-release is:	Multiple choice	0-10%; 11-20%; 21-30%; 31-40%; >40%
10. What is the financial structure of your company?	Multiple choice	Privately owned; Investor backed; Subsidiary of a parent company; Public company; Other:
11. Please describe in a few lines what you think is your business model?	Open-ended	
12. What other company important to you operates a similar business model?	Open-ended	
13. What is your current role at the company you work for?	Open-ended	
14. How many full time employees (FTE) work for your company?	Open-ended	
15. How many games did your company bring to market in the last two years?	Open-ended	
16. The focus of our company is on: (Drag and drop, put most preferred option on top)	Rank (1-6)*	Being profitable (i.e. business interests); Creativity and/or innovation in gameplay; Efficiency in our development processes; Building a sustainable relationship with the companies we work with; Building a sustainable relationship with the players of our games; Building sustainable relationships with companies that facilitate access to market (media, platforms, etc.)*
17. On average, what percentage of the development budget for your games is spent on marketing?	Slider (20 steps)	0-100%

* Order of choices randomized.
Questions sorted by 'type' (a-z)

APPENDIX C: PUBLICATIONS, PRESENTATIONS & KNOWLEDGE TRANSFER⁴³

Chapter 2: Fighting the Console Wars

Academic publications:

Rietveld, J. and Lampel, J. (2014). Nintendo: Fighting the Video Game Console Wars, *The Strategy Process* (in ed. Mintzberg, H. *et al.*), Fifth Edition, FT Press.

Chapter 3: Platform Complements and Demand Heterogeneity

Academic presentations:

- 2015 Job talk, *KU Leuven Faculty of Economics and Business*, Brussels, Belgium.
- 2015 Job talk, *LMU Munich, Organizations Research Group, ISTO-chair*, Munich, Germany
- 2014 Invited seminar presentation, *LUISS Guido Carli, Dept. of Management*, Rome, Italy
- 2014 Job talk, *USC Marshall School of Business, Department of Management and Organizations*, Los Angeles, CA.
- 2014 Job talk, *Rotterdam School of Management, Department of Strategic Management & Entrepreneurship*, Rotterdam, Netherlands.
- 2014 Job talk, *HEC Paris, Strategy and Business Policy Department*, Paris, France.
- 2014 Job talk, *HEC Montreal, International Business Department*, Montreal, Canada.
- 2014 Job talk, *Pace University, Lubin School of Business, Management & Management Science Department*, New York, NY.
- 2014 Paper presentation & poster session, *Platform Strategy Research Symposium*, Boston University, Boston, MA.

Practitioner Presentations:

- 2014 Invited presentation, *Entertainment Software Association (ESA)*, staff meeting, Washington, DC.
- 2014 Invited presentation, *Entertainment Software Association (ESA)*, Annual Consultants Day, Washington, DC.
- 2014 Video interview, *Entertainment Software Association (ESA)*, available: <http://youtu.be/-bbcL0i3yA>

⁴³ As of February 1st 2015 (dissertation submission date). Selected presentations under alternative title.

Chapter 4: New Horizons or Strategic Mirage?

Academic publications:

Broekhuizen, T.L.J., Lampel, J. and Rietveld, J. (2013). New Horizons or a Strategic Mirage? Artist-led-distribution Versus Alliance Strategy in the Video Game Industry. *Research Policy*, 42 (4), 954-964.

Academic presentations:

- 2012 Paper presentation, *32nd Annual Strategic Management Society Conference*, Prague, Czech Republic.
- 2012 Paper presentation, *Tilburg Innovation Conference*, Tilburg University, Tilburg, Netherlands.
- 2012 Invited seminar presentation, *Nottingham University Business School*, Ningbo, China.

Practitioner presentations:

- 2012 Invited conference presentation, *Digital Shoreditch*, London, United Kingdom.

Chapter 5: Game Changers

Academic presentations:

- 2014 Paper presentation, *30th EGOS Colloquium*, Rotterdam, The Netherlands.
- 2014 Paper presentation, *8th Annual NYU-Columbia Doctoral Student Conference*, New York, NY.
- 2013 Paper presentation & poster session, *Cass Business Model Workshop*, London, United Kingdom.

Practitioner publications:

Rietveld, J. and Dreunen, v. J. (2014). De-Risking Game Development in the Digital Era: Four Strategic Questions Every Game Company Should Ask Itself, *SuperData Research*, available: <http://www.superdataresearch.com/de-risking-game-development/>

Practitioner presentations:

- 2014 Invited presentation, *Game Developers Conference (GDC): Next*, Los Angeles, CA.
- 2014 Keynote presentation, *GameOn Finance*, Toronto, Canada.